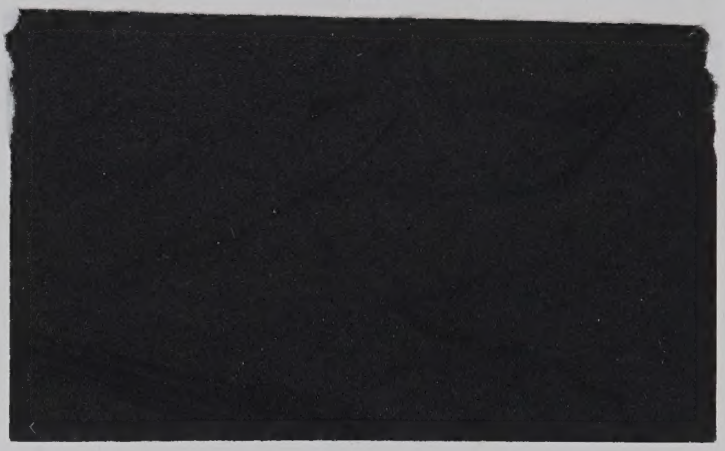
2480 SERIES
SIGNAL CONDITIONING
EQUIPMENT

OPERATING AND SERVICE MANUAL

HEWLETT PACKARD hp DYMEC DIVISION

HEWLETT hp PACKARD



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The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

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PRELIMINARY
MANUAL

(Stock Number 02480-9021P)

for

2480 SERIES
SIGNAL CONDITIONING
EQUIPMENT

DYMEC
A Division of Hewlett-Packard Co.
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THIS HANDBOOK, STOCK NO. 02480—9021P, APPLIES TO THE FOLLOWING INSTRUMENTS:

HP 2480A	DC Excitation Source	Serial Prefix 631-, 731-
HP 2480C	Excitation Coupler	Serial Prefix 717-, 733-
HP 2480K	Excitation Coupler	Serial Prefix 631-
HP 2481A	Resistance Bridge	Serial Prefix 631-, 731-
HP 2482N	Monitor Function Selector	Serial Prefix 632-

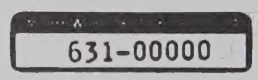
IT INCLUDES OPTIONAL MODIFICATIONS:

Within handbook: HP 2480A M1 & M2, and HP 2481A M1 thru M8

At rear of handbook:

INSTRUMENT IDENTIFICATION

Each instrument is identified by a two-section, 8-digit Serial Number.



SAMPLE
Instrument
Identification
Decal

The first 3 digits are a Serial Prefix (type) Number, the last 5 digits identify each individual instrument. ALL INSTRUMENTS WITH THE SAME SERIAL PREFIX ARE THE SAME. Later instruments (higher Serial Prefixes), are covered by a green "Updating Supplement", at the back of each handbook. Earlier instruments (lower Serial Prefixes), are covered by a blue "Backdating Supplement", also at the rear of the handbook.

Option No(s). identify Modifications made to the basic equipment to meet your particular requirements. Some Optional (standard) Modifications may be described within, or at the rear of the handbook as listed above.

MODIFICATION DESCRIPTIONS

Any special Modifications to the equipment described in this handbook are explained in "Handbook Supplements" added at the rear of this handbook.

READ through Section 2 of the basic handbook and all accompanying "Handbook Supplements" before attempting installation or operation of your equipment, as some special procedures may be necessary.

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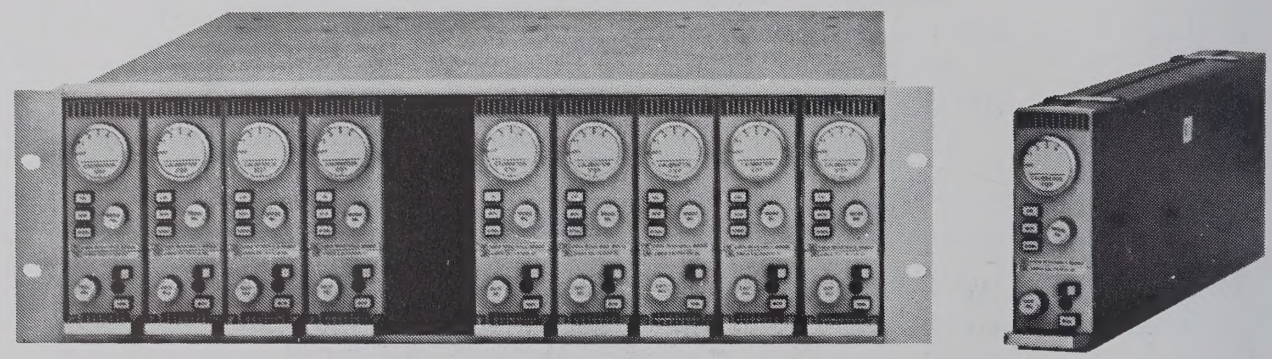


FRONTISPIECE

HP-2480 SERIES SIGNAL CONDITIONING EQUIPMENT

SECTION 1

GENERAL DESCRIPTION

1-1 INTRODUCTION

The HP-2480 series Signal Conditioning Equipment is designed for use in conjunction with resistive data-sensing devices – such as strain gage transducers, potentiometric transducers, resistance thermometers, etc – to measure physical data using the Wheatstone Bridge technique. Figure 1-1 illustrates the basic configuration of such a system.

The HP-2480 series equipment provides the necessary dc excitation source for the bridge and the operating, balancing and calibrating components for 1, 2 or 4-active arm transducers. The equipment consists of four modular units:

a. HP-2480A DC Excitation Source
b. HP-2481A Resistance Bridge
c. HP-2480K Excitation Coupler
d. HP-2482N Monitor Function Selector

The units may be used individually or collectively to form a wide variety of circuit configurations. Special design emphasis has been placed on the stability, floating and guarding characteristics. As a consequence the equipment can be used with high quality guarded digital voltmeters and data amplifiers with a high degree of accuracy and negligible common mode noise problems.

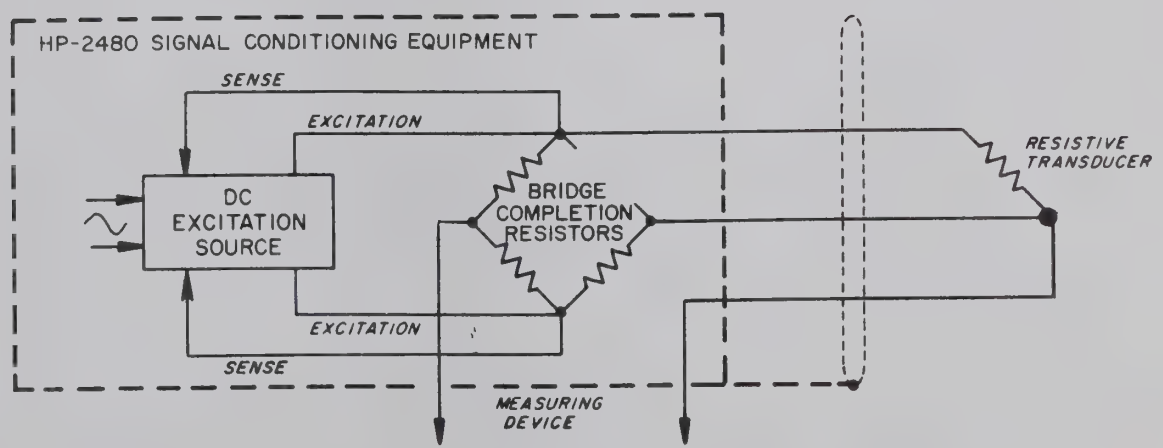


Figure 1-1 Wheatstone Bridge Measurement Technique

1-2 HP-2480A DC EXCITATION SOURCE

The HP-2480A DC Excitation Source (Figure 1-2) is an adjustable 30 volts, 200 milliamperes supply for excitation of the bridge circuit. Basically, the Excitation Source consists of a highly stable reference power supply, a differential dc amplifier and mode switching circuits. The reference power supply provides an output voltage which is adjustable between 0 and 6 volts. This is applied as one input to the differential amplifier. The second input to the differential amplifier is a "Sense" voltage which is a function of voltage or current changes in the bridge circuit. The reference voltage plus the signal feedback ratio from the bridge determines amplifier output. The phasing is such that the changes are cancelled, thus maintaining a constant voltage or constant current condition. The Excitation Source switching circuits determine the polarity of the excitation voltage and select the mode of operation (Paragraph 1-6).

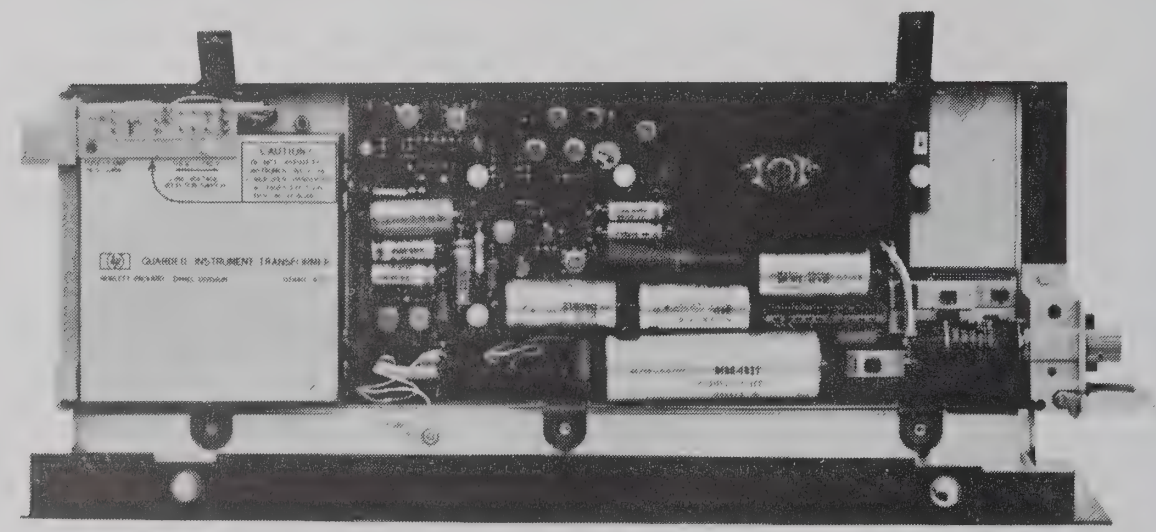
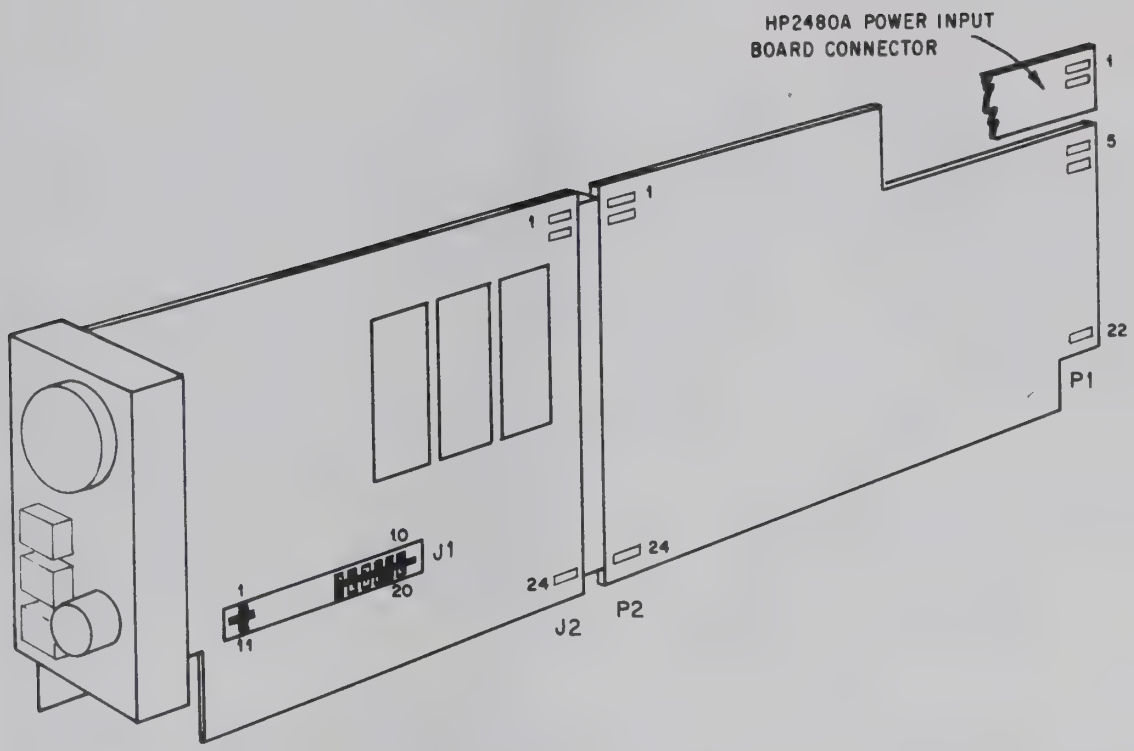
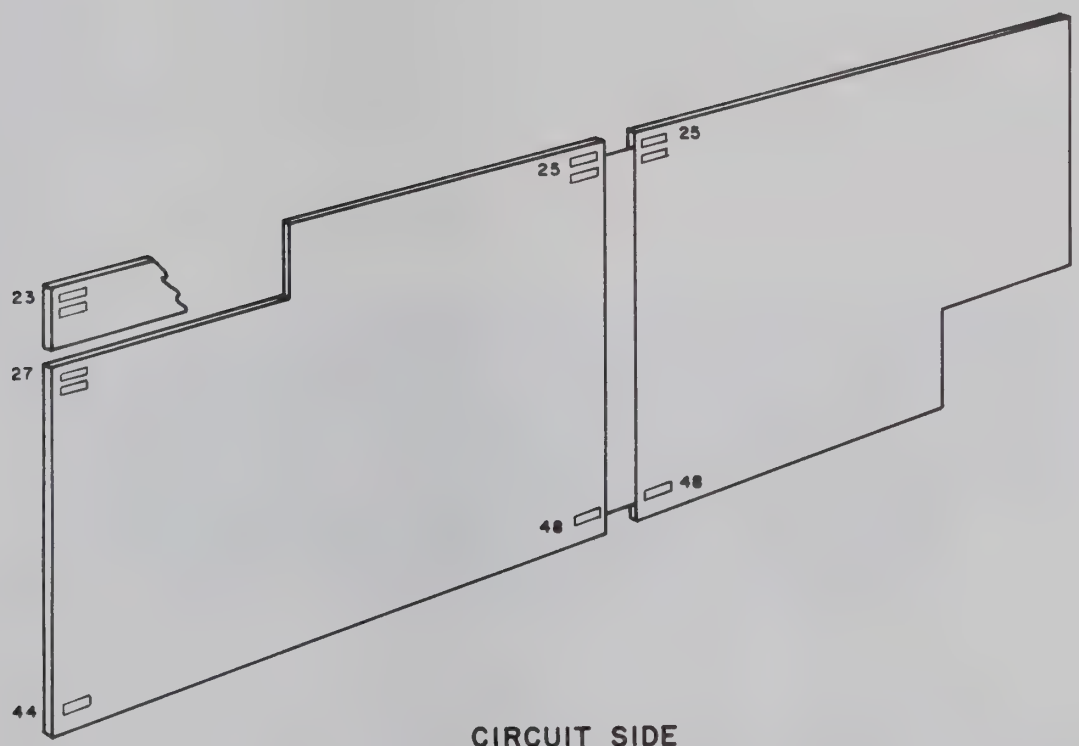


Figure 1-2 HP-2480A DC Excitation Source

The HP-2480A consists of an AC Power Input Board A2 (shown in the upper left hand corner of Figure 1-2), a guarded instrument transformer, and an etched circuit board A1 which contains the remainder of the electronics. The AC Power Input Board requires a small portion of the combining case receptacle that receives the instrument. The remaining portion of the receptacle is used by the Resistance Bridge. See Figure 1-3.



COMPONENT SIDE



CIRCUIT SIDE

FIGURE 1-3 HP-2480A AC POWER INPUT BOARD AND
HP-2481A CONTROL AND RESISTOR BOARDS

1-3 HP-2481A RESISTANCE BRIDGE

The HP-2481A Resistance Bridge provides the necessary bridge completion and calibration resistors, together with the associated switching circuits. One, two and four active arm configurations are provided for.

The HP-2481A Resistance Bridge components are mounted on two printed circuit boards which plug together, end to end (Figure 1-4). The front board, known as the "Control Board" contains the switching and control components; those components which do not change with changing transducer configurations. The rear board, the "Resistor Board", contains all the components which change to meet the requirements of the specific transducer in use. This arrangement makes it practical and economical to keep a number of resistor boards already loaded to match different transducers. To simplify loading, the rear boards are over-printed to indicate where the bridge completion and calibration resistors should be connected.

The calibration resistors are switched in circuit by special "Reed" type relays which inherently have very long term, low contact-resistance characteristics. In the basic HP-2481A a 2-pole relay switches one calibration resistor in shunt with one transducer arm or a pair of resistors in shunt with opposite arms of the transducer. Modification M1 through M5 provde additional relays for selecting from two up to six different calibration resistors, or resistor pairs. The relays are energized when an external 24 volts dc supply is applied to individual control lines connected to the relays. As an alternative arrangement Modification M6 provides a six-position CALIBRATION STEP switch which routes the 24 volts energizing supply to the selected relay for local selection of the calibration relay.

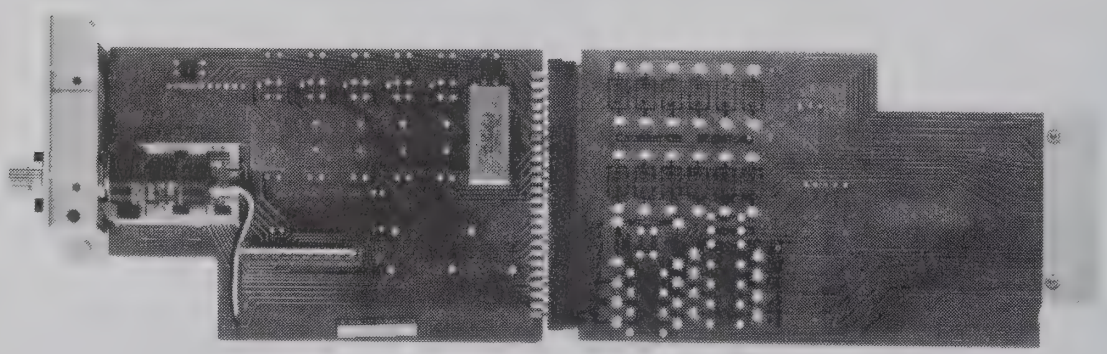


Figure 1-4 HP-2481A Resistance Bridge

Modification M7 to the HP 2481A requires a control board with stock no. 02481-6006 whereas the standard module uses a control board with stock no. 02481-6005. The M7 control board is furnished with three relays. One relay provides the single or double shunt calibration step. The two remaining polarization relays determine whether the calibration step will be negative or positive. The M7 control board may receive Modifications M1, M2, and M3. Since the polarization relays occupy the locations normally occupies by the relays for M4 and M5 in the standard module, calibration steps are necessarily limited to four. Modification M8 provides a 9-position CALIBRATION STEP switch. The switch provides for local selection of up to 4 positive calibration steps, up to 4 negative calibration steps, and an OFF position. Without Modification M8, a particular calibration step and its polarity may be controlled by external switches.

1-4 HP-2480K EXCITATION COUPLER

The HP-2480K Excitation Coupler (Figure 1-5) permits several transducer channels to be excited from a single power supply; either an HP-2480A DC Excitation Source or any other source chosen by the user. The Excitation Coupler merely links the excitation source, made available at the HP-2480 series combining case mother board, to the HP-2481A Resistance Bridge. Switches are included to permit polarity reversal and monitoring of excitation voltage or current, as selected by the HP-2482N Monitor Function Selector.

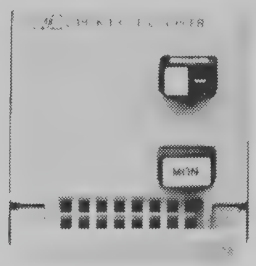


Figure 1-5 HP-2480K Excitation Coupler

1-5 HP-2482N MONITOR FUNCTION SELECTOR

The HP-2482N Monitor Function Selector (Figure 1-6) enables the user to select excitation voltage, excitation current or the transducer signal voltage for monitoring by an external voltmeter. Current is monitoried by means of a 1-ohm standard resistor. A front panel switch is provided for function selection.

Figure 1-6 HP-2482N Monitor Function Selector

1-6 MEASUREMENT TECHNIQUES

The HP-2480 series Signal Conditioning Equipment may be used to make measurements in three modes:

a. Constant Voltage Mode
b. Constant Current Mode
c. Linear Mode

The constant voltage and constant current modes, shown in Figures 1-7 and 1-8 respectively, are conventional. In the constant voltage mode the voltage across the bridge is held constant by the DC Excitation Source differential amplifier, which senses and compensates for any changes in bridge resistance. Changes in transducer resistance, brought about by physical stimulus, unbalances the bridge thus providing an output signal representative of the stimulus.

In the constant current mode the current through the bridge is held constant by the DC ExcitationSource differential amplifier. The amplifier senses the voltage drop across a series current-sensing resistor (Rs) and compensates for any changes in line voltage or load resistance.

The linear mode is unique to the HP-2480 Signal Conditioning Equipment. This ingenious arrangement virtually eliminates the high non-linearity characteristics inherent in single active arm, constant voltage and constant current configurations. Refer to paragraph 2-4 for a description of linear mode operation.

In normal constant voltage operation a 2% change in variable arm resistance will typically result in a non-linearity error in the order of 1% of the reading. With the HP-2480 equipment operating in the linear mode, a 100% change in variable arm resistance will cause a non-linearity error of less than 0.1% – an overall improvement in linearity of 500 times.

1-7 PHYSICAL DESCRIPTION

The HP-2480 series Signal Conditioning Modules are housed in compact versatile instrument cases having front panel dimensions of 4-3/4 × 1-3/4 inches and a depth of 15 inches (Figure 1-10). A single case will accommodate an HP-2481A Resistance Bridge and either an HP-2480A DC Excitation Source or an HP-2480K Excitation Coupler (Figure 1-11). The HP-2480 series instrument cases are intended for mounting in the associated HP-12521A Combining Case (Frontispiece) which provides the necessary inter-module wiring and the forced air cooling required for optimum performance. The combining case, which occupies 5 inches of panel space in a standard 19-inch wide instrument rack will accommodate up to 10 modules. However, any number of combining cases may be interconnected to provide for any desired number of modules. A single interconnecting cable is used to connect the combining cases.

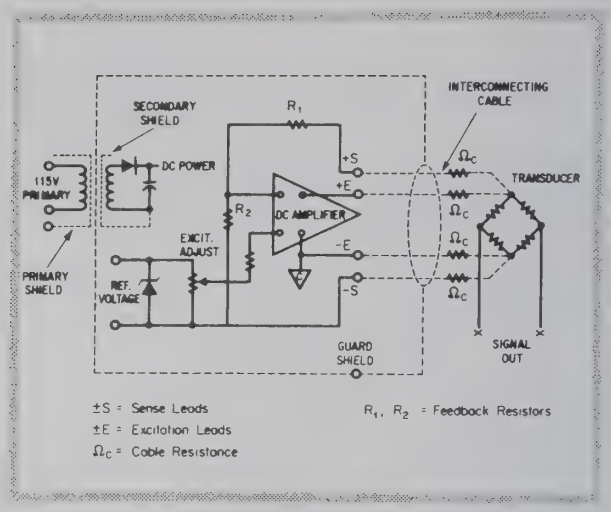


FIGURE 1-7
CONSTANT VOLTAGE MODE

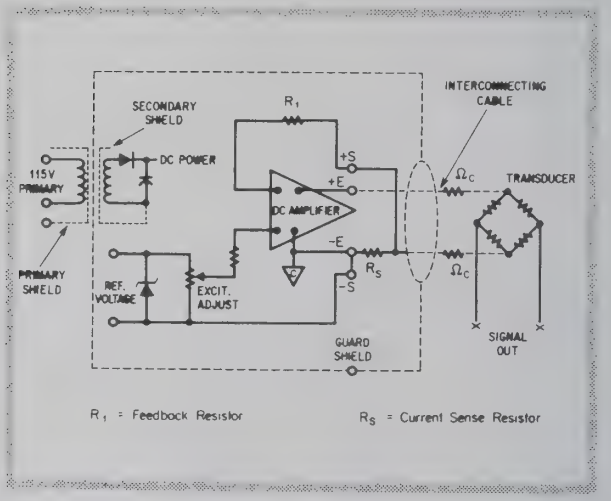


FIGURE 1-8
CONSTANT CURRENT MODE

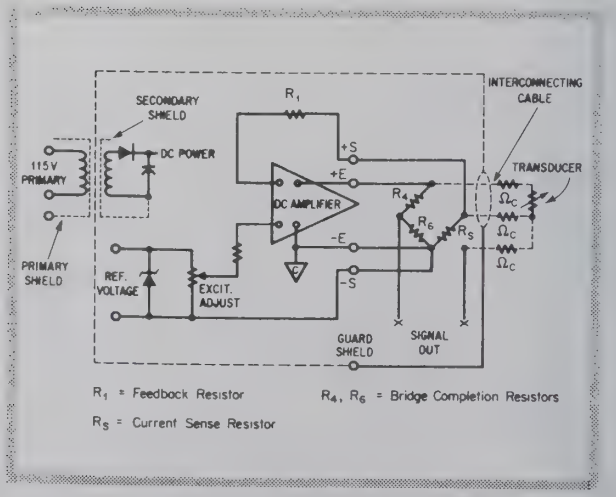


FIGURE 1-9
LINEAR MODE

Figure 1-10 HP-2480 Series Modules Installed in Instrument Case

8 DISASSEMBLY

Loading of the HP-2481A's resistor board, adjustment of controls other than those operated on the front panel, and maintenance will require removal of the HP-2481A module from the HP-2480A or HP-2480K instrument case.

CAUTION

Contamination of certain PC board surfaces can result in loss of instrument performance, particularly under conditions of high humidity. When handling PC boards, avoid touching the board's exposed male connectors usually located at the board's front edge.

'or the HP-2482N Monitor Function Selector, only the rear (jumper) board can be emoved for the addition of jumpers if required.

-9 SPECIFICATIONS

Specifications are listed on pages 1-11 and 1-12.

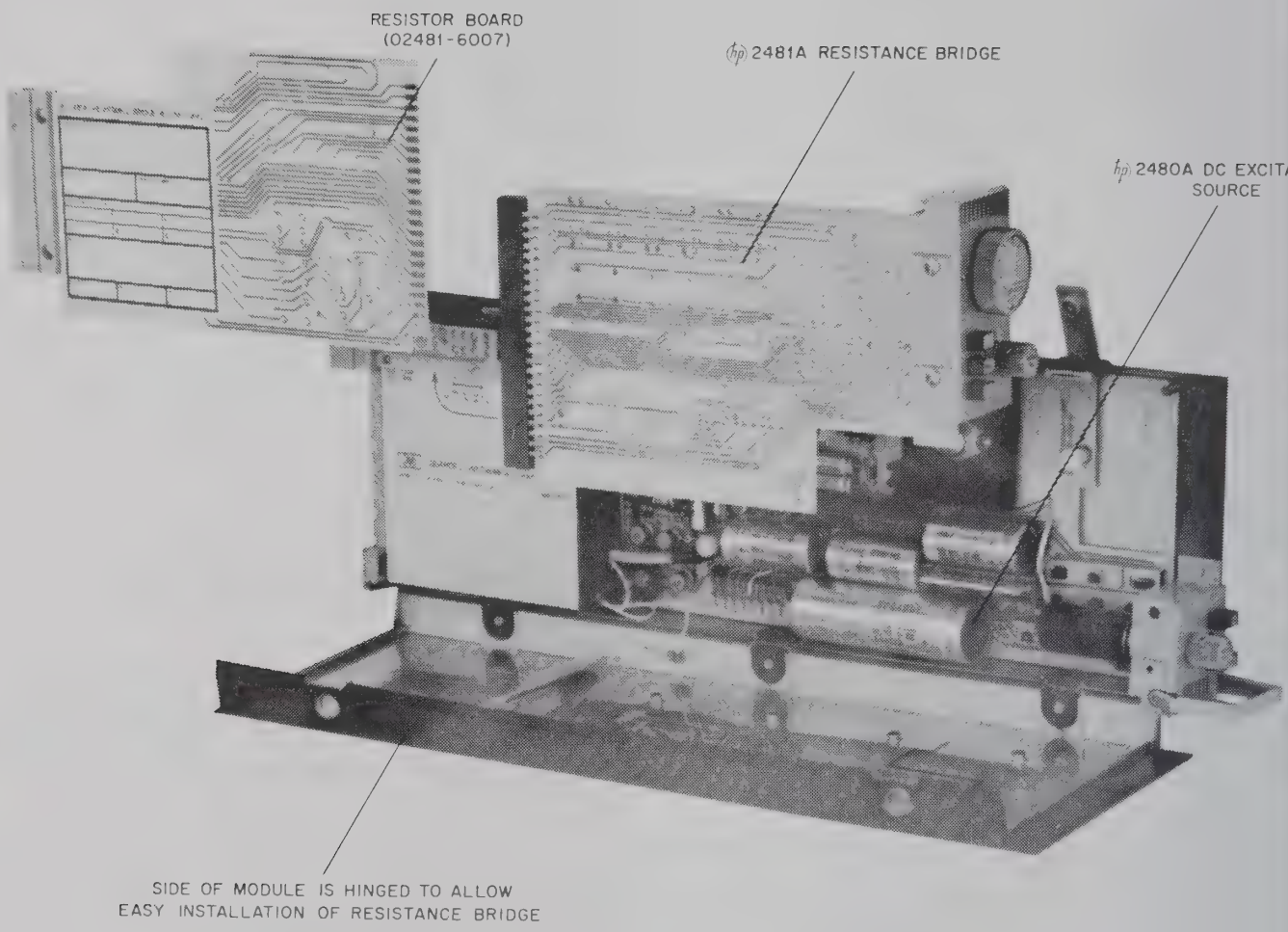


FIGURE 1-11

HP-2480 SERIES INSTRUMENT CASE, SHOWING EXCITATION SOURCE AND RESISTANCE BRIDGE INSTALLATION

Performance figures hold for all combinations of permissible deviations in line voltage, load and environmental conditions when supplied with minimum 1 cfm forced air.

CONSTANT VOLTAGE MODE

OUTPUT VOLTAGE

0.1 to 30v dc, continuously adjustable. Internal switch reduces span to 0.1 to 6v.

OUTPUT CURRENT

0 to 200 ma.

OUTPUT VOLTAGE RESOLUTION

Standard: 0.03% of full scale output. This is equivalent to 9 mv on full span or 1.8 mv on reduced span.

With Vernier (Option M1): 0.0004% of full scale. This is equivalent to 120 μv on full span or 24 μv on reduced span.

NOISE OUTPUT

Ripple: RMS total of all power line frequency components < 120 μv at 200 ma, reducing to 30 μv at 0 ma. Specification holds for output voltage from 0.1 to 30v, load > 10Ω.

Injected Current: Current at power line frequencies flowing between guard shield and/or ± excitation output leads is < 120 na rms at 400 cps, reducing to 15 na at 50 cps.

Thermal Noise: 175 μv rms maximum, measured in 0 to 40 kc bandwidth across excitation leads.

REGULATION

Load Regulation: Change in output voltage for load current change of 200 ma is < 600 μv at 30v output, reducing to 300 μv at 0.1v output. Specification holds for loads > 10Ω.

Line Regulation: Change in output voltage for ±10% line voltage change (from 115v nominal) is < 600 μv at 30v output, reducing to 300 μv at 0.1v output. Specification holds for loads > 10Ω.

Transducer Cable Resistance: With remote error sensing, load and line regulation specifications deteriorate by < 50 μv per ohm of loop resistance. (If remote error sensing is not used, load regulation specification deteriorates by 200 mv per ohm of loop resistance. Remote sense or excitation lead loop resistance should not exceed 20Ω.)

Short Circuit Load: Sustained short circuit does not damage instrument. Short circuit load current internally adjustable from 80 to 300 ma. Factory set to 280 ma. (Instrument resumes normal operation upon removal of short.)

Transient Load Regulation: <2 ms for recovery to within 0.01% of static load regulation specification, for resistive load current change of 200 ma.

Turn On/Off Transient: < 3v peak. (Energy < 100 mw-sec.)

OUTPUT VOLTAGE STABILITY

Time: Less than 100 μv + 0.004% of output voltage setting, per 24-hour period. (With fixed load, 30-minute warmup.)

Temperature: Less than 170 μv + 0.005% of output voltage setting, per °C change in ambient (for temperature change rate 40°C/hour maximum). Remote error sensing assumed.

Transducer Cable Effect: Temperature coefficient of resistance (0.4% per °C) of transducer cable introduces error < 0.0004% of output voltage, per °C, per ohm of loop resistance. Remote sense or excitation lead loop resistance should not exceed 20Ω. Load resistance > 10Ω.

CONSTANT CURRENT MODE

OUTPUT VOLTAGE

Compliance: 0 to 24v.

OUTPUT CURRENT

1 to 200 ma.

OUTPUT CURRENT RESOLUTION

Standard: 0.03% (60 μa) of full scale output.

With Vernier (Option M1): 0.0004% (8 μa) of full scale output. Vernier span is 120 μa minimum.

NOISE OUTPUT

Ripple: RMS total of all power line frequency components <2 μa for zero load resistance, reducing to 0.2 μa at 3000Ω load resistance.

Injected Current: Current at power line frequencies flowing between guard shield and/or ± excitation output leads is < 120 na at 400 cps, reducing to 15 na at 50 cps.

Thermal Noise: 3 μa rms maximum, measured in 0 to 40 kc bandwidth in excitation leads.

REGULATION

Load Regulation: For any change of resistive load (within 0 to 3K range) exercising full voltage compliance of the 2480A, output changes < 3 μa +0.0035% of the output current setting.

Line Regulation: Change in output current for ±10% line voltage change (from 115v nominal) is < 10 μa at 200 ma output, reducing to 3 μa at 1 ma output.

,ansient Load Regulation: < 25 ms +0.5% of cycle period for recovery to within 0.01% of static load regulation specification, for resistive load change of 10%.

Turn On/Off Transient: < 3v peak. (Energy < 100 mw-sec.)

OUTPUT CURRENT STABILITY

Time: Less than 1 μa + 0.004% of output current setting, per 24-hour period. (With fixed load, 30-minute warmup.)

Temperature: Less than 2 μa + 0.005% of output current setting, per °C change in ambient (for temperature change rate 40°C/hour maximum).

LINEAR MODE

(This mode of operation is suitable for bridge configuration with 3 arms fixed and 1 arm variable.)

BRIDGE SENSING ARM

Permissible resistance range 30Ω to 3K. (Ratio of variable arm to sensing arm resistance should not exceed 4:1.)

BRIDGE COMPLETION ARM

Permissible resistance range 60Ω to 20K.

EXCITATION VOLTAGE

Voltage across bridge 0.1 to 30v, continuously adjustable.

EXCITATION CURRENT

Sense Resistance	Current Range*
30Ω	0 to 200 ma
1K	0 to 6 ma
3K	0 to 2 ma

(*Continuously adjustable)

SIGNAL OUTPUT VOLTAGE

12v maximum span. (Voltage at signal leads can vary from -3 to +9v.)

BRIDGE VARIABLE ARM

Sense Resistance	Variable Arm Range
30Ω (fixed)	0 to 120Ω
1K (fixed)	0 to 4K
3K (fixed)	0 to 12K

SIGNAL OUTPUT LINEARITY

Better than ±0.1% for ±100% change in bridge variable arm resistance.

SENSE RESISTOR CURRENT RESOLUTION

Standard: 0.03% of full scale excitation current available.

With Vernier (Option M1): 0.0004% of full scale excitation current available.

NOISE OUTPUT

Ripple: RMS total of all power line frequency components through bridge active arm < 2 μa for zero arm resistance, reducing exponentially to 0.2 μa at 3K arm resistance.

Injected Current: Current at power line frequencies flowing between guard shield and/or ± excitation leads is < 120 na rms at 400 cps, reducing to 15 na at 50 cps.

Thermal Noise: 3 μa rms maximum, measured in 0 to 40 kc bandwidth in excitation leads.

REGULATION

Load Regulation: Change in current through bridge sensing arm, as variable arm is changed through permissible range (see Bridge Variable Arm) is < 10 μa at 200 ma, reducing to 3 μa at 1 ma.

Line Regulation: Change in current through bridge sensing arm for ±10% line voltage change (from 115v nominal) is < 10 μa at 200 ma, reducing to 3 μa at 1 ma.

Transient Load Regulation: < 25 ms +0.5% of cycle period for recovery to within 0.01% of static load regulation specification for a resistive load change of 10%.

Turn On/Off Transient: < 3v peak. (Energy < 100 mw-sec.)

OUTPUT CURRENT STABILITY

Time: Less than 1 μa + 0.004% of output current setting, per 24-hour period. (With fixed load, 30-minute warmup.)

Temperature: Less than 2 μa + 0.005% of output current setting, per °C change in ambient (for temperature change rate 40°C/hour maximum).

GENERAL SPECIFICATIONS

ENVIRONMENTAL CONDITIONS

Ambient Temperature:
Operating: 0 to + 55°C
Non-Operating: -40 to + 75°C

Relative Humidity
Operating/Non-Operating: to 95%, +25 to +40°C.

Altitude
Operating: 15,000 ft.
Non-Operating: 25,000 ft.

POWER REQUIRED

115/230v ±10%, 50 to 400* cps. Power consumption approximately 8.5w at full load. Conversion 115 to 230v operation by internal switch. (*Combining Case restricted to 50-60 cps. 400 cps operation on special order.)

DC ISOLATION

10,000 megohms minimum for sense leads, excitation leads or signal leads to ground or ac line.

GUARD

Capacitance (guard shield connected): Capacitance between circuitry within guard shield and ac power line or ground, 10 pf max.

Breakdown: Guard shield to ac power line or ground, 500 vdc minimum.

OPTIONAL MODIFICATIONS

(Order by M-number.)

M1. Excitation Adjust Vernier: Permits fine adjustment of output from front panel. Add $15.00.

M2. Potentiometer Vernier Adjust: Fine adjustment of output provided by multi-turn potentiometer, with screwdriver adjustment of span. Add $15.00.

PRICE

Model hp 2480A DC Excitation Source, (installed in signal conditioning module case) $245.00.

SECTION 2

INSTALLATION AND OPERATION

2-1 UNPACKING

The HP-2480 series Signal Conditioning Equipment is shipped in a specially constructed container, designed to provide maximum protection during transit. However, as soon as possible after receipt of the equipment, it should be carefully unpacked and visually inspected to ensure no physical damage has occurred. When the visual inspection is complete, and if no damage is found, the equipment should be installed in preparation for electrical checking.

If the instrument is damaged, the carrier and the nearest Hewlett-Packard field office should be notified immediately. The field office will arrange for the repair or replacement of the equipment. The shipping container and packing materials should be retained for inspection.

2-2 INSTALLATION

The HP-2480 series Signal Conditioning Modules are intended for operation in the associated HP-12521A Combining Case, which provides the necessary inter-module wiring and the forced air cooling required for optimum performance. The combining case, which occupies 5 inches of panel space in a standard 19-inch wide instrument rack will accommodate up to ten modules. However, any number of combining cases may be interconnected to provide for any desired number of modules. A single interconnecting cable is used to connect the combining cases. Special 2-foot and 8-foot cables (HP-12521-6010 and HP-12521-6011 respectively) are available for this purpose.

The HP-2480 series Signal Conditioning Equipment should be installed in a location which will permit a transducer cable loop resistance of 20 ohms or less. Providing this requirement is met the equipment may be placed in any location where the environmental conditions are within the limits specified in Section 1. The ac power required by the signal conditioning equipment is either 115 or 230 volts ±10%, 50/400 cps, at approximately 8.5 watts. The combining case fans are 50/60 cps with 400 cps fans available on special order. In addition a 24 volts ±20% dc supply is required for operation of the calibration circuit relays. The supply should be capable of providing 10 ma for each relay used.

External connections to the signal conditioning modules are made via connectors located on the combining case mother board, which is accessible by a door at the rear of the case (Figure 2-1). Three connectors are provided for each module. Fifteen-pin connectors, J11 thru J20, are used for connections to the transducer and nine-pin connectors, J21 thru J30, are used for connections to the signal measuring or monitoring device. Signals from these connectors are routed, together with 24-volt external power and inter-module wiring to 44-pin connectors, J1 thru J10, which mate with the modules.

Figure 2-2 provides details of the wiring and functions relating to one set of three connectors. This is typical and applicable to the other nine sets.

2-3 WIRING CONFIGURATIONS

The external (transducer) wiring associated with the signal conditioning equipment may vary widely depending on the type of transducer used and the type of measurements required. However, in practice three basic arrangements are most often used:

a. Single active arm configuration
b. Two active arm configuration
c. Four active arm configuration

These are described herein.

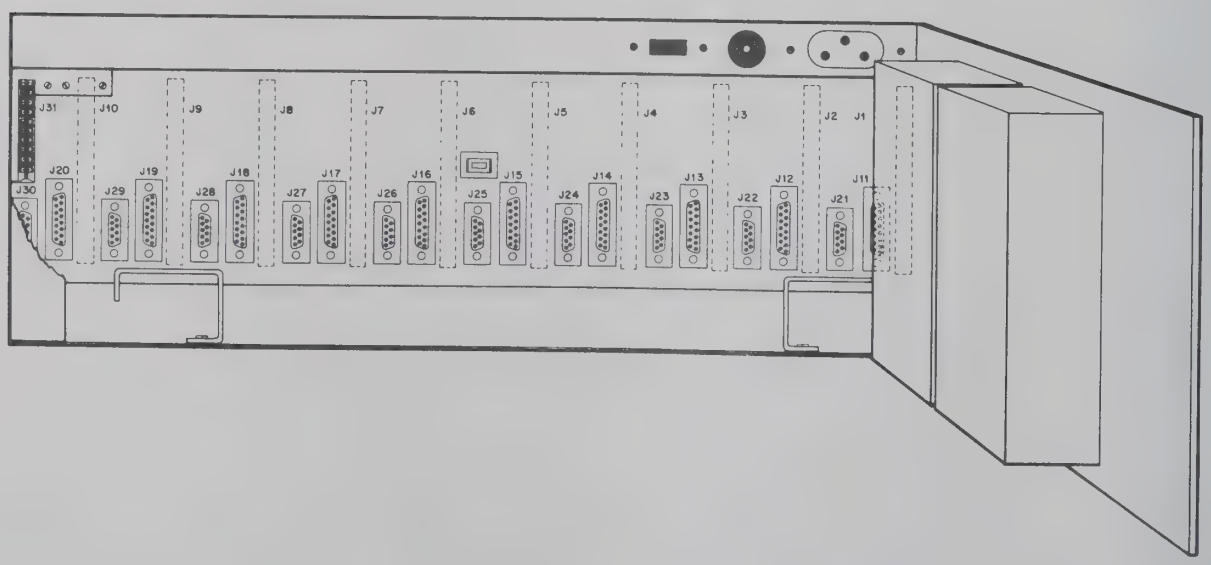
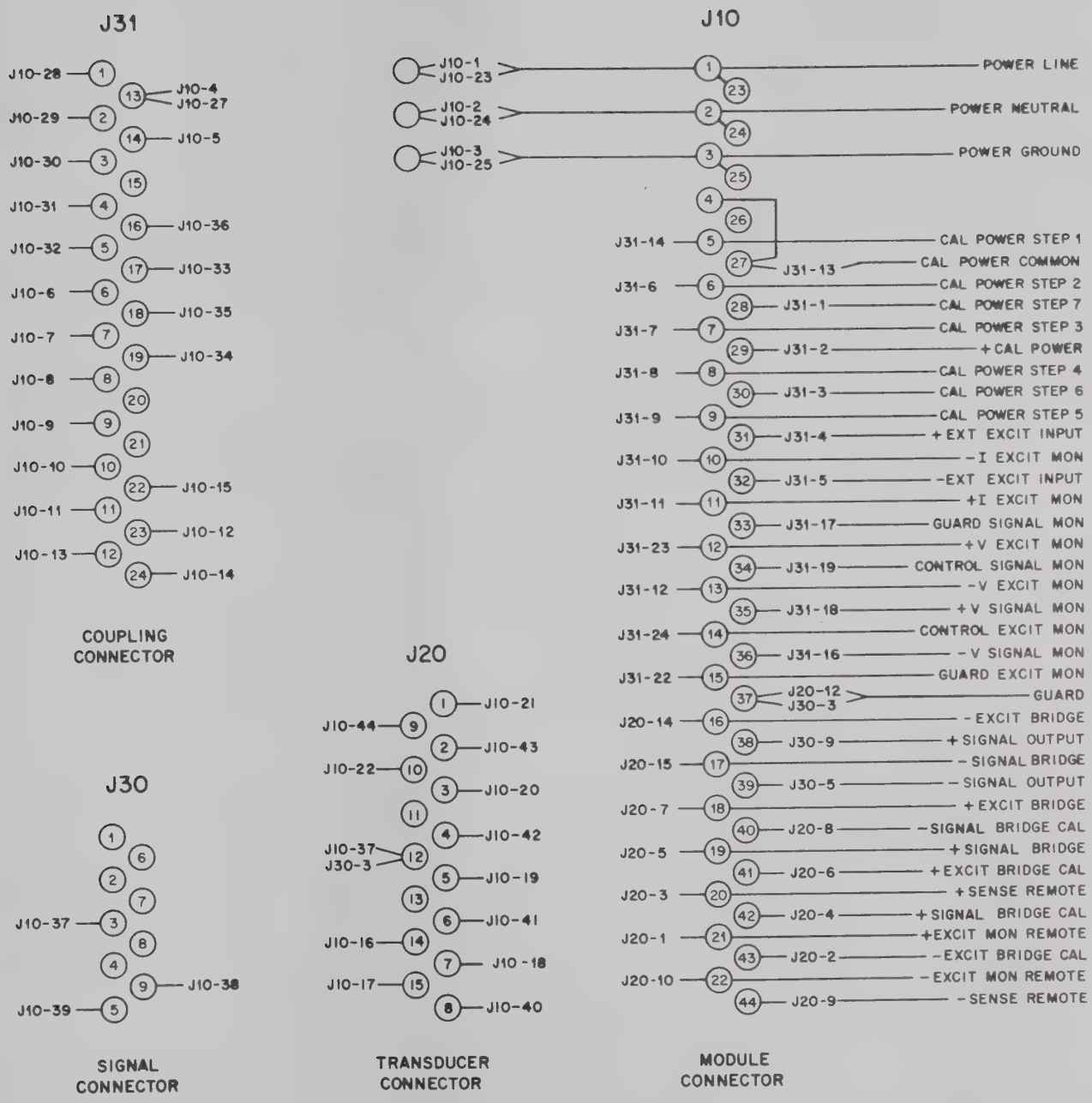


Figure 2-1 HP-12521A Combining Case Connectors



NOTE PINS 1 THRU 15, AND 23 THRU 36 ON J10 ARE LINKED TO THE CORRESPONDING PINS ON J1 THRU J9 CONNECTORS ARE SHOWN LOOKING AT THE REAR OF THE MOTHER BOARD

FIGURE 2-2 MOTHER BOARD INTERCONNECTIONS

2-4 Single Active Arm Configuration

The single active arm configuration is that in which the transducer is a variable resistor forming one arm of the Wheatstone Bridge circuit and the remaining three arms are bridge completion resistors, contained within the signal conditioning equipment. Transducers of the resistance thermometer and strain gage type are those most commonly used in such an arragement.

Single active arm circuits may be operated in constant voltage, constant current or linear modes of operation. Figure 2-3 illustrates the single active arm, constant voltage circuit, and the HP-2481A Resistance Bridge circuit-board loading, required to achieve this. The values of the bridge completion resistors (R7, R9 and R10) and the calibration resistor (R1B) are chosen by the user to suit the particular transducer in use.

It will be noted that in the constant voltage circuit shown, the excitation monitoring and sensing is done locally at the completion resistors. This is normal with single active arm circuits since this is the most convenient place to measure the complete excitation voltage. However, if it is considered desirable, the positive monitoring and sensing connection may be made at the positive side of the transducer with the negative connection remaining at the completion resistors, thus reducing the effects of the resistance of the cable carrying the positive excitation voltage. This will of course use an additional conductor which should be connected between the transducer and pin 1 on the mother board transducer connector. Also, the EXC. MON switch is set to REMOTE and J7 and J11 must be jumpered to complete the local connection.

The external wiring for the single active arm, constant current mode is the same as that for the constant voltage mode. However, the mode switch (Item 1, Figure 2-7) in the HP-2480A DC Excitation Source should be set for constant current operation. This connects the "Sense" input of the excitation source differential amplifier through current sensing resistor R39 which results in constant current flow through the transducer. See Figure 4-1. The SENSE switch on the HP-2481A is inoperative. Refer to note following 2-12(b) concerning balance circuit operation.

Figure 2-4 illustrates the circuit and circuit-board loading for the linear mode of operation. This arrangement has the advantage that it virtually eliminates the non-linearity in the relationship between the change in transducer resistance and the bridge output. Such non-linearity becomes significant as the percentage change in transducer resistance increases.

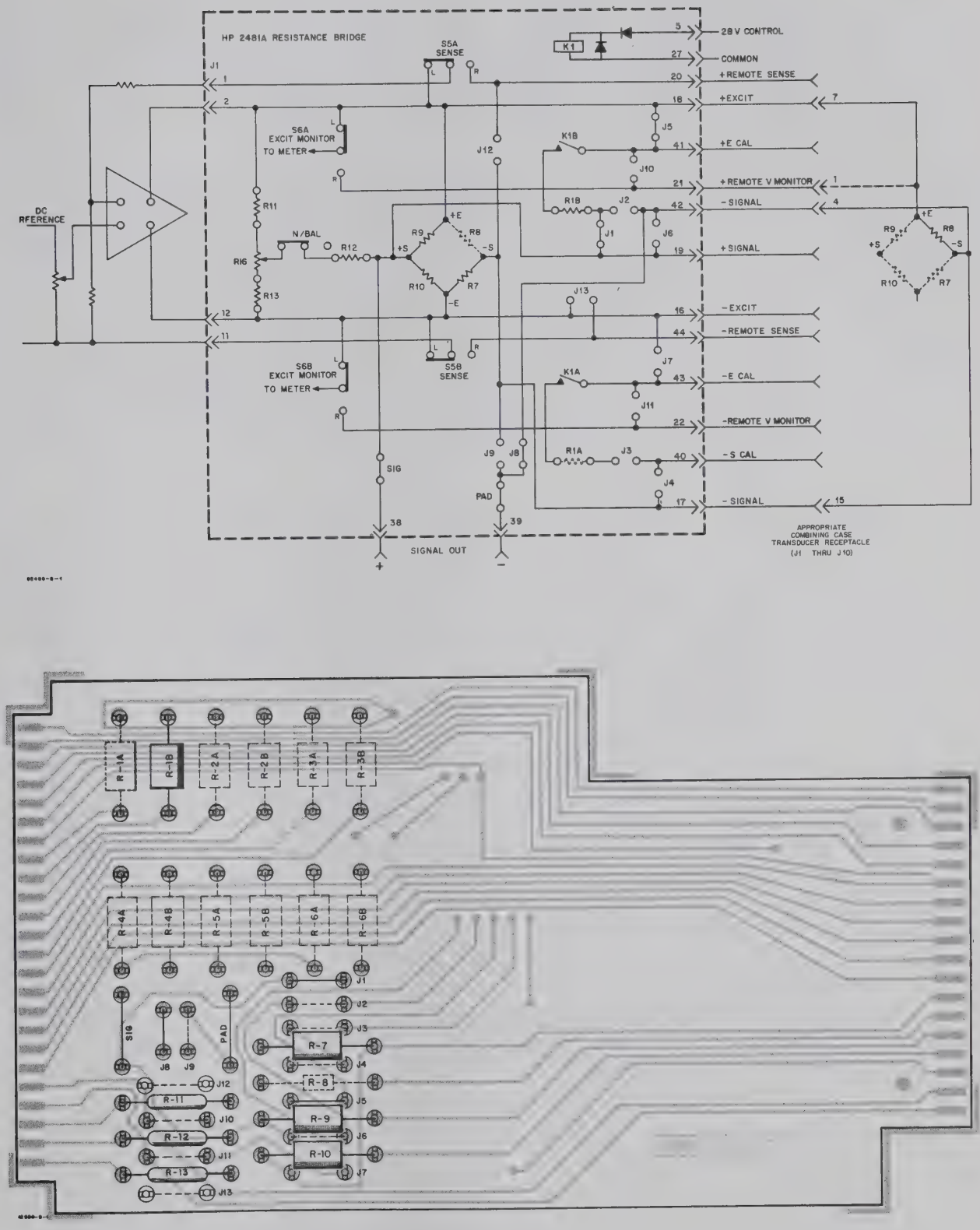


Figure 2-3. Single Active-Arm, Constant Voltage Mode: Circuit and Resistor Board Loading

It may be seen by comparing Figure 2-3 with Figure 2-4 that the linear mode wiring is similar to the constant voltage wiring; the only difference being in the "Sense" connection. In the linear mode this connection is made to the junction of the transducer and the bridge completion resistor R7.

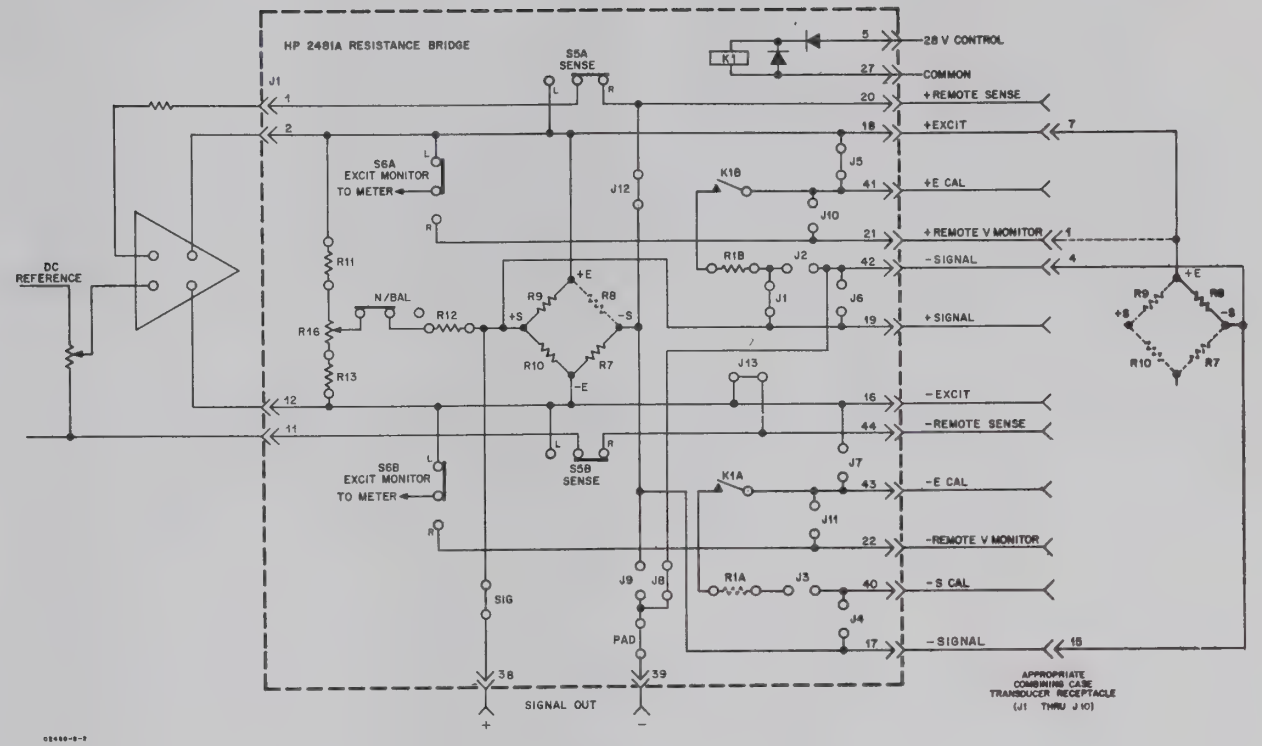
This holds the voltage across R7 constant and therefore maintains a constant current through both R7 and the transducer. This means that the voltage acorss the bridge varies in proportion to the changes in transducer resistance and therefore the voltage at the +SIGNAL corner of the bridge changes linearly with respect to the transducer resistance changes.

With the normal single active arm, constant voltage arrangement (Figure 2-3) the output signal is the result of changes in the voltage drop across the transducer R8 with respect to the constant voltage maintained across the bridge. It might appear that the change in the voltage drop across R8 should be linear with respect to change of R8, but this is not so.

When R8 changes, the total value of R8 plus the bridge completion resistor R7 changes and the current through R7 and R8 changes. If R8 increases, the current decreases, but the current decrease is proportional to some resistance value that is the sum of R8 and R7. This lack of direction proportionality between changes in current due to changes in R8 causes the output signal taken from the bridge to be non-linear with respect to changes in R8. The degree of non-linearity varies with the ratio between the values of R7 and R8. Non-linearity is more pronounced at high ratios of R8 to R7.

In the linear mode (Figure 2-4) the differential amplifier maintains a constant voltage across sensing resistor R7 thereby achieving a constant current through both R7 and R8, the transducer. Note that the bridge excitation voltage varies in relation to changes in R8 that are sensed by R7. The result is that the signal output changes linearly with respect to changes in R8.

Calibration in any single active arm operating mode is accomplished by energizing one of the calibrate relays. In calibration step 1, contacts of realy K1 will shunt R9 with R1B causing a +calibration step. If desired a -calibration step could be obtained by connecting the left end of J7 to the left end of J5. On schematics in Figures 2-3 and 2-4 this connection would be from the bottom of J5 to the top of J7, shunting R10.



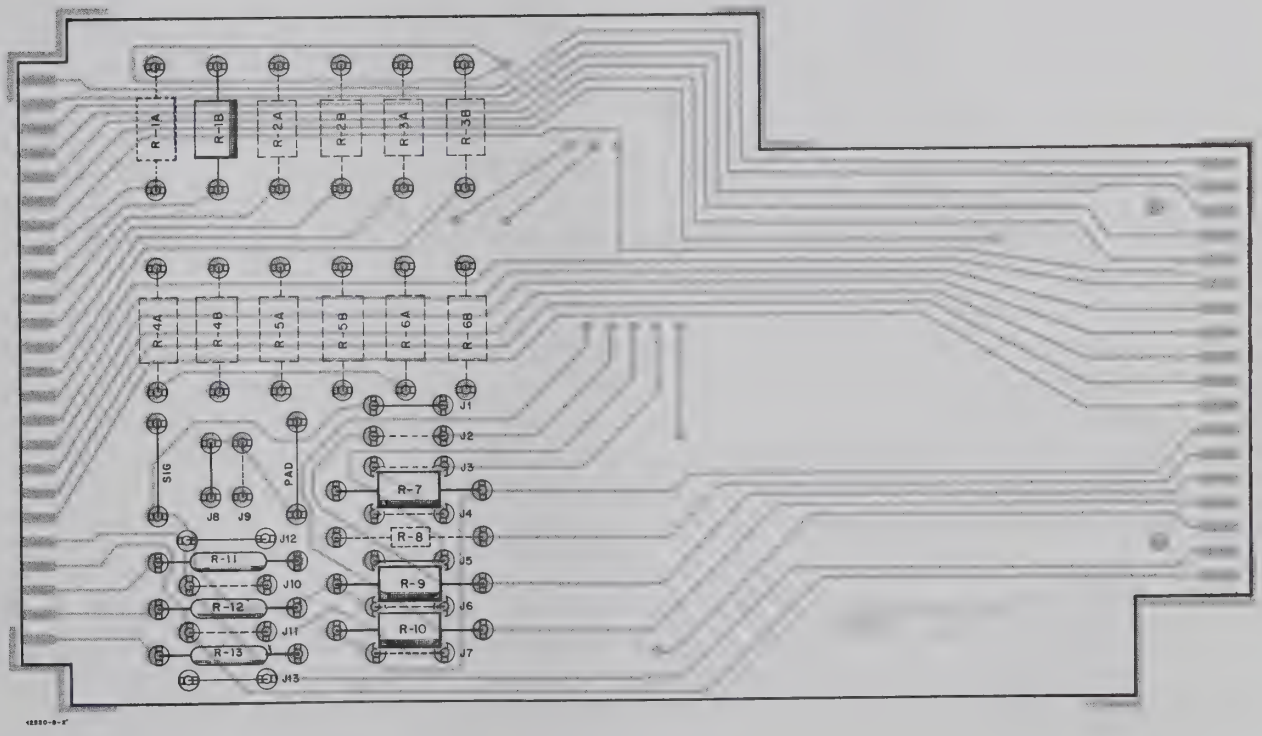


Figure 2-4. Single Active-Arm, Linear Mode: Circuit and Resistor Board Loading

2-5 Two Active-Arm Configuration

The two active-arm configuration is that in which the resistive data sensing device forms two arms of the Wheatstone Bridge circuit and the remaining two arms are bridge completion resistors, contained within the signal conditioning equipment. Transducers of the pressure and force measuring type sometimes use such an arrangement.

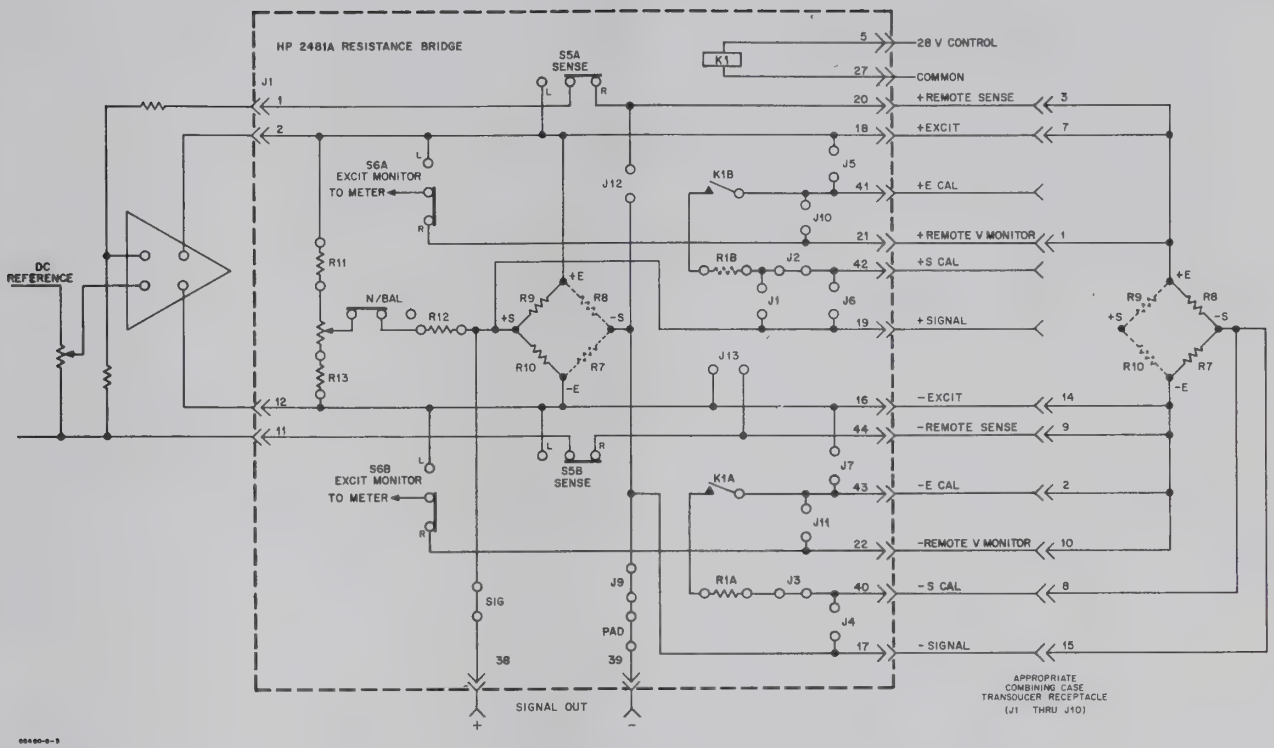
Two active-arm circuits may be used in the constant voltage and constant current modes of operation. Figure 2-5 illustrates a two active-arm, constant voltage circuit, and the HP-2481A Resistance Bridge circuit-board loading required to achieve this. The values of the bridge completion resistors (R9 and R10) and the calibration resistor (R1B) are chosen by the user to suit the particular transducer in use.

The 2480 series permits connection of excitation voltage monitoring and/or sensing circuits locally or at the transducer. In the circuit shown, the excitation voltage monitoring and sensing is done remotely, that is, at the actual transducer rather than at the signal conditioning equipment. Four separate wires are connected to the transducer for this purpose. This arrangement has the distinct advantage that the values measured are the actual values present at the transducer. It eliminates consideration of the voltage drop in the excitation lines which occurs as a result of the inherent resistance of the lines and the monitoring or sensing currents flowing therein.

However, if it is desired to monitor and/or sense the excitation voltage locally, at the signal conditioning equipment, and thus dispense with two or four of the wires to the tranducer, this may be done. The EXC. MON switch and/or the SENSE switch (Figure 2-8, Items 8 and 7 respectively) are merely placed in their LOCAL positions to achieve this.

In the constant current mode of operation, which is achieved by operation of the "Mode" switch on the HP-2480A DC Excitation Source, only the excitation, signal monitoring and calibration wires are required. Excitation sensing is done within the signal conditioning equipment. Excitation monitoring may be done remotely at the transducer as shown in Figure 2-5 or locally with the EXC. MON switch as described in the preceding paragraph.

Calibration is accomplished by the shunting of R7 with R1A using relay K1 and its contacts K1A. This produces a +calibration step. Double shunt calibration could be accomplished by jumpers at J5 and J6 to shunt R9 and R1B upon the closure of contacts K1B.



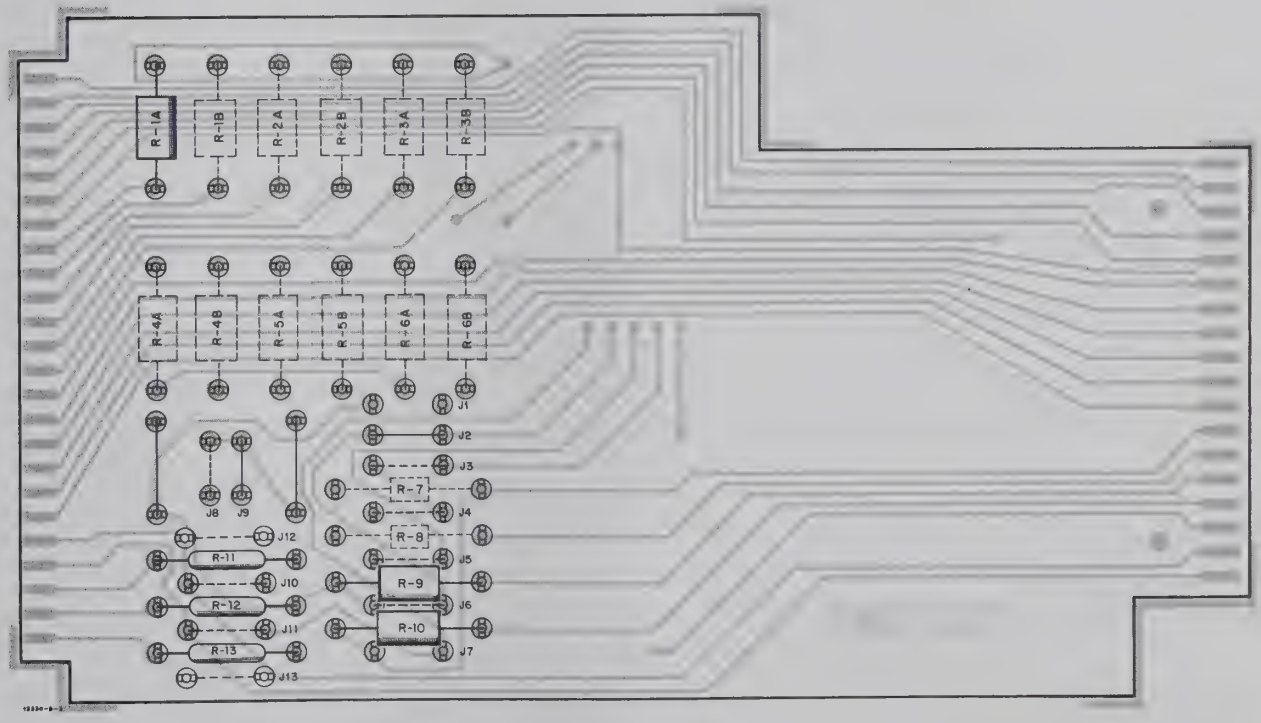


Figure 2-5. Two Active-Arm, Constant Voltage Mode: Circuit and Resistor Board Loading

2-6 Four Active-Arm Configuration

The four active-arm configuration is that in which the resistive data-sensing device forms all four arms of the Wheatstone Bridge circuit. Usually four active-arm transducers are of the strain gage type or are user fabricated transducers designed for specific applications. The four active-arm transducer is inherently more sensitive than the single and two active-arm devices and provides a high order of linearity in the relationship between the transducer resistance and the change in bridge output.

As in the case of the two active-arm configuration, the four active-arm arrangement may be operated in constant voltage and constant current modes. Figure 2-6 illustrates a four active-arm, constant voltage circuit, and the HP-2481 Resistance Bridge circuit-board loading required to achieve this. The excitation voltage may be monitored and sensed either locally or remotely.

2-7 CONTROLS AND JUMPERS

Before attempting to operate the HP-2480 series Signal Conditioning Equipment, the user should obtain a thorough understanding of the purpose and functions of the various operating controls. Such information is presented in Figures 2-7 thru 2-10 and Tables 2-1 thru 2-4.

Table 2-1 HP-2480A DC Excitation Source Controls

Item	Control	Function
1	CONSTANT VOLTAGE or CONSTANT CURRENT Switch	Places the HP-2480A DC Excitation Source and the associated transducer circuits in either the constant voltage or constant current mode of operation. When the switch is in the forward position (nearest the front panel) the equipment operates in constant current mode. The rear position is for the constant voltage mode.
2	GAIN X1 or GAIN X6 Switch	In the contant voltage mode it switches the effective gain of the dc excitation source differential amplifier to either 1 (X1) or 5.5 (X6). In the X6 position, the power supply output is 0.1 to 30 vdc; in the X1 position the output is 0.1 to 6 vdc. The X1 position must be used in the linear mode. The switch is inoperative in the constant current mode.

HEWLETT PACKARD DYMEC DIVISION

SIGNAL CONDITIONING EQUIPMENT

model 2480

UPDATING MANUAL SUPPLEMENT 20 Nov.67

MANUAL IDENTIFICATION

Manual Serial Prefixed: A
Manual Printed: 4-67
Manual Part Number: 02480-9021P

SUPPLEMENT DESCRIPTION

The purpose of this supplement is to correct manual errors (Errata) and to adapt the manual to instruments having serial prefixes listed in the table below. Enter the new information (or the Change Number, if more convenient) into the appropriate places in the manual.

Instrument Serial	Changes
Errata	1 thru 9
B	10
C	11
D	12 thru 16

Instrument Serial	Changes
Errata	17, 18

Instrument Serial	Changes

CHANGE	DESCRIPTION
1	Page 1-4, Section 1-3, 2nd Paragraph: Add new sentence at end of Paragraph as follows: "Bridge completion, calibration, and balance resistors are not furnished with the resistor board except on special order."
2	Page 1-4, Section 1-3, 3rd Paragraph: Add new sentence at end of Paragraph as follows: "The external 24-volt dc supply should be floated (positive or common leads not connected to earth ground) or common Mode noise problems may be introduced".
3	Page 2-1, Section 2-2, 1st Paragraph: Change last sentence to read: "Special 4-1/2-foot and 15 foot cables (HP 12521-6010 and HP 12521-6011, respectively) are available for this purpose."
4	Page 2-2, 1st Paragraph and in Figure 2-1: Change "J11 thru J20" to "J1 thru 10","J21 thru J30" to "J11 thru J20", "J1 thru J10" to "XA1 thru XA10","J31" to "XA11" (on Figure 2-1 only).
5	Page 2-3, Figure 2-2: Delete and replace with Drawing C12521-6001-2 furnished with this supplement.

INSTRUMENT	PREFIX-A	PREFIX-B	PREFIX-C	PREFIX-D
2480A	631	731	740	747-
2480C	717	733	740	747-
2480K	631			747-
2481A	631	731	740	747-
2482N	632			747-

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CHANGE	DESCRIPTION
6	Page 2-10, Section 2-7, 1st Paragraph: Add new sentences at end of Paragraph as follows: "A summary of jumpers and resistors which may be installed in the HP 2481A Resistance Bridge is provided in Section 3-9. Paragraphs 2-7A through 2-7C provide information on other jumpers which may be installed".
7	Page 2-17. Add new Paragraphs after Table 2-4 as follows: 2-7A. Install two jumpers (furnished as accessories) across the EXTERNAL EXCITATION JUMPERS terminals of the combining case control board (A11) to furnish excitation for the operation of HP 2480C or HP 2480K Excitation Couplers from a power source external to the combining case. See Figure 4-5. Excitation is normally introduced at connector J2 and may be routed via J1 to other combining cases. If the excitation is to be furnished to all combining case positions, set the CHAN 1-5 EXTERNAL EXCIT. BUSS switch on the transducer side of the mother board to ON. If the excitation is to be furnished only to channels 6-10, set the switch to OFF. If it is desired to isolate the excitation busses of this combining case from the supplied excitation, the jumpers are omitted. 2-7B. Install a jumper (furnished as an accessory) across terminals labelled R1 in the HP 2480K Excitation Coupler if the full excitation voltage is to be supplied to the bridge from the excitation busses of the combining case mother board. Or install a selected resistor to decrease the excitation voltage supplied to the bridge. See Figure 4-3. 2-7C. Install jumpers (furnished as accessories) on the jumper board of the HP 2482N Monitor Function Selector if the 2482N is to selectively monitor the parameters of the nine bridge circuit contained in this combining case only. See Figure 4-4. These jumpers are omitted if the parameters to be measured are returned from J2 of the first combining case to the transducer receptacle now associated with the 2482N's location in the combining case.
8	Drawings D12521-9008 (3) furnished as part of this supplement provide interconnection information between the combining case and typical 2480 series instrument configuration.

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CHANGE	DESCRIPTION
9	Page 4-5, Figure 4-5: Delete and replace the Drawing C12521-6008-2 attached to this supplement.
10	General. For the HP 2480A and HP 2481A with Serial Prefix 731-and the HP 2480C with Serial Prefix 733, the BRIDGE BAL and EXCIT ADJ potentiometer control assemblies are modified. The clutch action afforded by and "O" ring in the assemblies of older instruments was abandoned in favor of a spring washer and simple friction loading of shaft rotation. This modification may be made on instruments in the field and is suggested for any instrument that has a clutch or clutch adjustment problem.
11	General, for HP 2480A, HP 2480C and HP 2481A instruments with Serial Prefix 740- , the BRIDGE BAL and EXCIT ADJ potentiometer control assemblies are modified. The modification described in change 10 of this supplement did not provide sufficient friction loading of shaft rotation in all instruments, therefore change 10 is superseded by this change. This modification may be made on instruments in the field and is suggested for any instrument prior to Serial Prefix 740- that has a clutch adjustment problem or insufficient shaft friction.
12	General. Prior to Serial Prefix 747-, printed-circuit board connectors were not required to be oriented during assembly in accordance with actual pin numbering. All numeric pin numbers were assigned in accordance with the position of the connector on the board. Starting with Serial Prefix 747- to all instruments of the 2480 Series Signal Conditioning Equipment, the connectors are oriented during assembly and the actual alpha-numeric pin numbers of each connector are used in all documentation. Therefore, the attached schematics replace manual illustrations as listed below:

Title and Drawing No. of Schematic	Replaces Manual Figure.
2480 DC Excitation Source (D02480-6007-2)	4-1
2481A Resistance Bridge (D02481-9001-1)	4-2
2480K Excitation Coupler (C02480-6011-2)	4-3
2482N Monitor Function Selector (C02482-9001-1)	4-4
Control Board (C12521-6008-2)	4-5
2481A-M7 Resistance Bridge (D02481-9002-1)	4-6
2480C Excitation Coupler (C02480-6009-2)	A-4
Mother Board (C12521-6001-2)	2-2

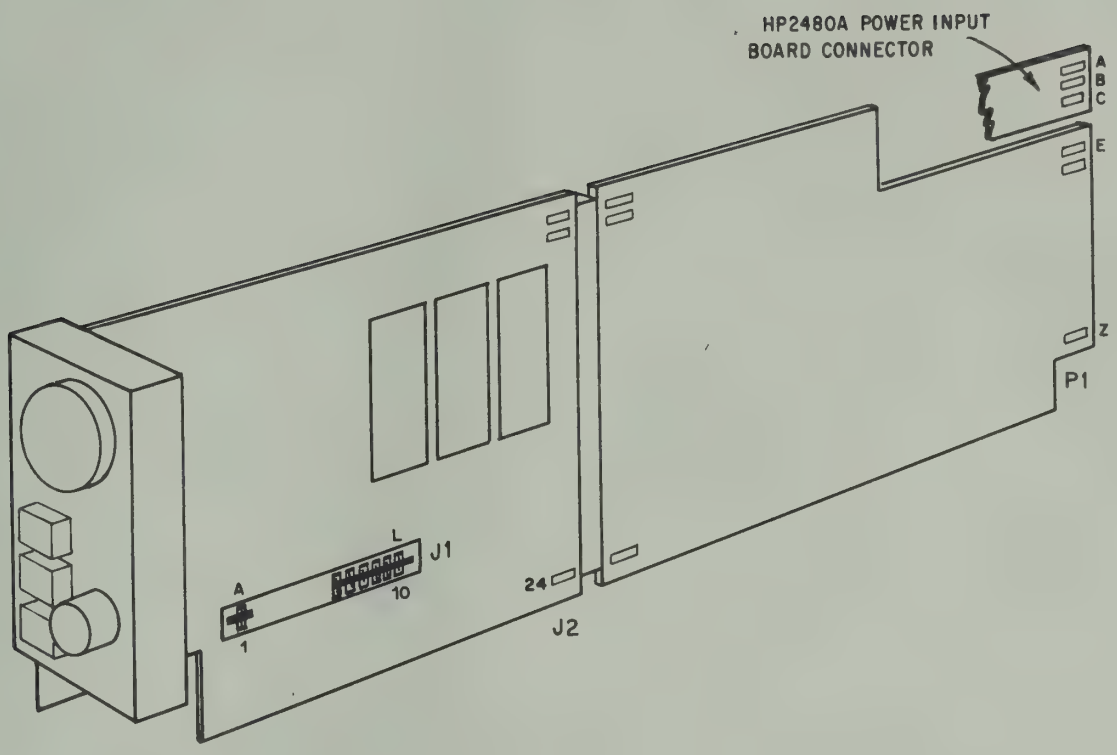
CHANGE	DESCRIPTION
13	Page 1-3, Figure 1-3: Delete and replace with Figure on page 5 of this supplement.
14	Pages 2-5, 2-7, 2-9, and 2-11: On Figures 2-3 through 2-6, change pin numbers shown within dashed-line block as tabulated below:

Old Pin No.	5	27	20	18	41	21	42	19	16
New Pin No.	E	5	X	V	19	Y	20	W	T
Old Pin No.	44	43	22	40	17	39	38	11	12
New Pin No.	22	21	Z	18	U	17	16	A	B

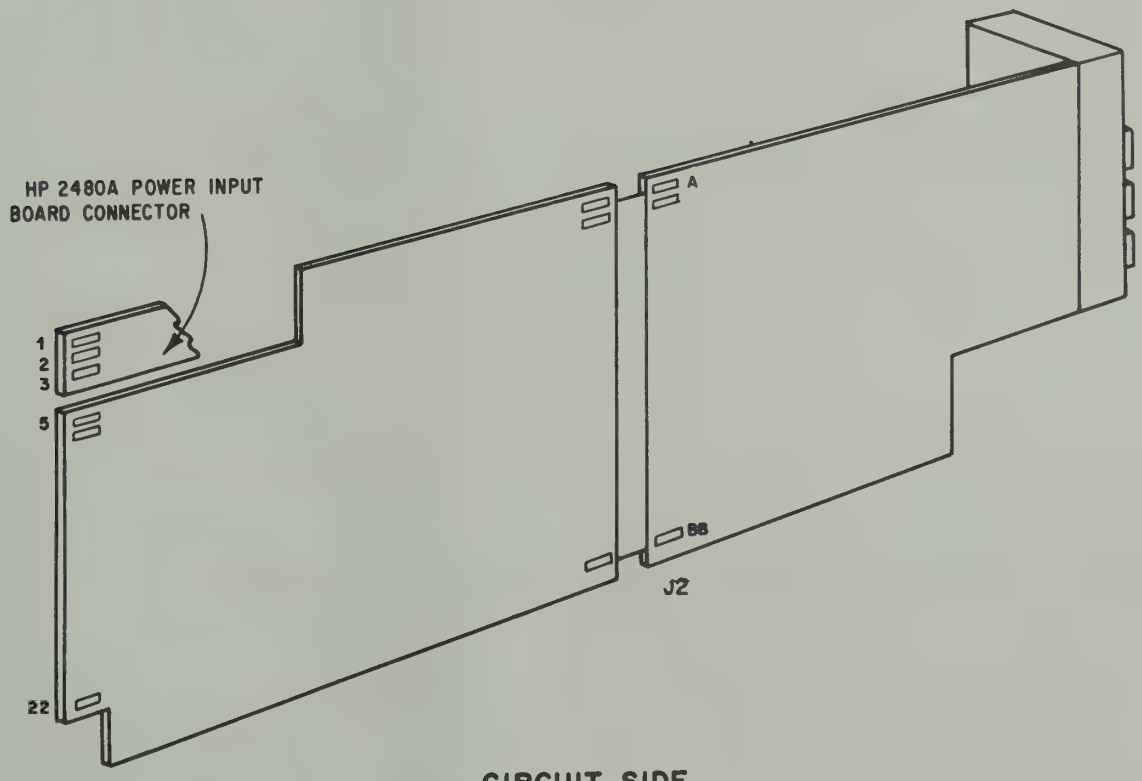
15	Page 3-3, second complete paragraph: Change "(J1-2 and J1-12)" to read "(J1-2 and J1-B)".
16	Page 3-5: Paragraph starting with "Figure 4-2: also omits ---: Delete word "pin-for-pin".
17	Page 3-8, second paragraph from bottom: Change "J1 through J10" to "XA1 through "XA10" (two places) and "J21 through J30" to "J11 through J20".
18	Page 2-17: Delete CAUTION and replace with new paragraph 2-8A and new CAUTION as follows: "2.8A. In the linear or constant current mode of operation, a potential of approximately 45 volts dc is impressed across the bridge completion resistors of the 2481A Resistance Bridge if the transducer opens up (as it would, for example, in the destructive testing of materials). To prevent damage to the bridge completion resistors, it is recommended that they be 5-kilohm resistors or greater. Where large resistance values are not allowable, adjust the current limiter of the 2480A DC Excitation Source for the maximum safe output current. Note that disconnecting the transducer from an operational 2480A will produce the same effect as an open-circuited transducer.

CAUTION

Be sure that the excitation lines are terminated at a transducer and controls of the 2480A/2481A combination are set properly before installing an instrument in the Combining Case."



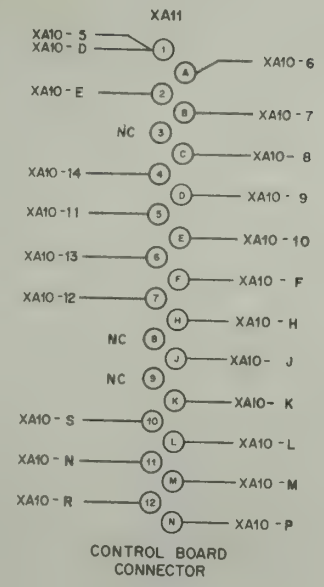
COMPONENT SIDE



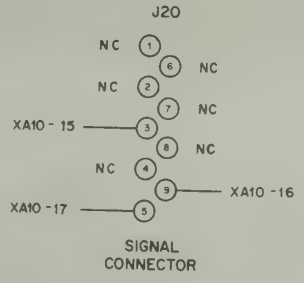
CIRCUIT SIDE

FIGURE 1-3 HP-2480A AC POWER INPUT BOARD AND
HP-2481A CONTROL AND RESISTOR BOARDS

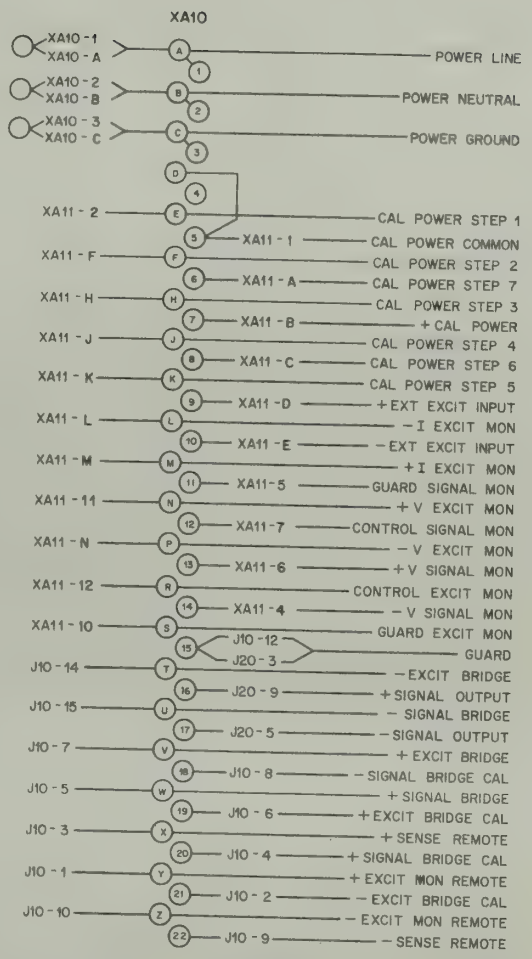
MOTHER BOARD 12521-8001 (NO PREFIX)



CONTROL BOARD CONNECTOR



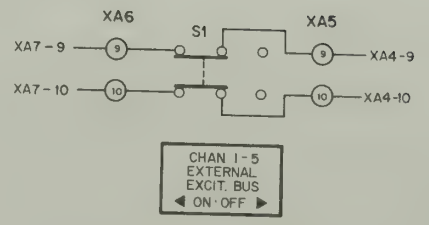
SIGNAL CONNECTOR

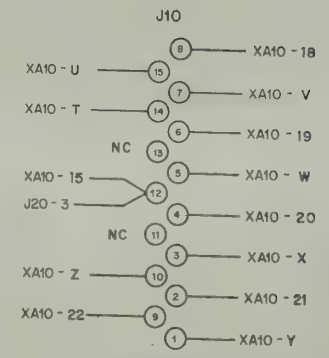


MODULE CONNECTOR

NOTES:

1. PINS 1 THRU 14, AND A THRU S ON XA10 ARE LINKED TO THE CORRESPONDING PINS ON XA1 THRU XA9.
2. WIRING FROM XA10 TO J10 AND J20 IS TYPICAL FOR THAT FROM XA1 TO J1 AND J11 THROUGH XA9 TO J9 AND J19.
3. CONNECTORS ARE SHOWN LOOKING AT THE REAR OF THE MOTHER BOARD.





TRANSDUCER CONNECTOR

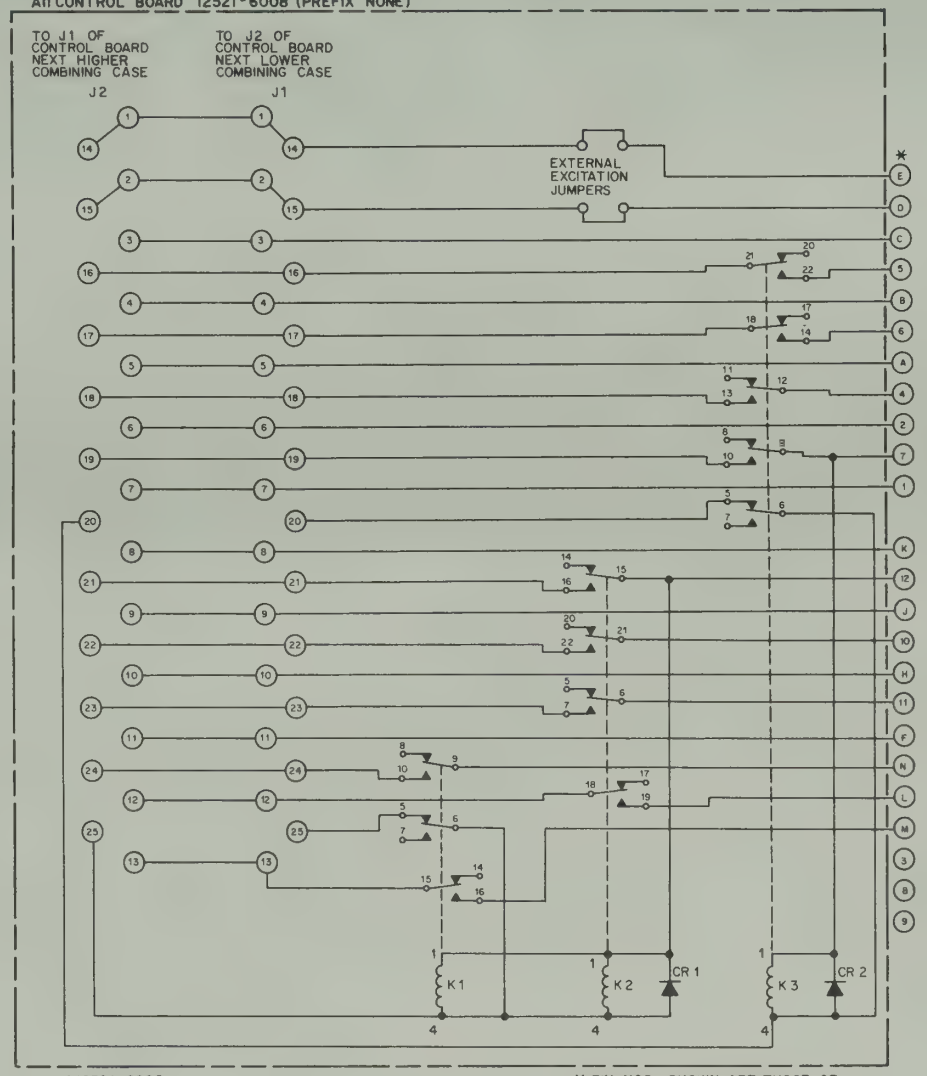
C12521-6001-S

SUPERCEDES C-12521-6001-2 REV.C DATED 5-25-67

		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: DECIMALS± FRACTIONS± ANGLES± ALL SURFACES√	DRAWN BY CB / DATE	MOTHER BOARD WIRING DIAGRAM	HEWLETT PACKARD DYMEC DIVISION 395 Page Mill Road Palo Alto California 94306
			CHECKED BY		
		MATERIAL	ENG APPD HYLKE / 10-3-67		
		STK NO	PROJ APPD		
NEXT ASSY	USED ON	FINISH OR TREATMENT	MFG APPD		
APPLICATION				SCALE	C-12521-6001-2 CODE 04404 SHEET 1 of 1

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL

A11 CONTROL BOARD 12521-6008 (PREFIX NONE)

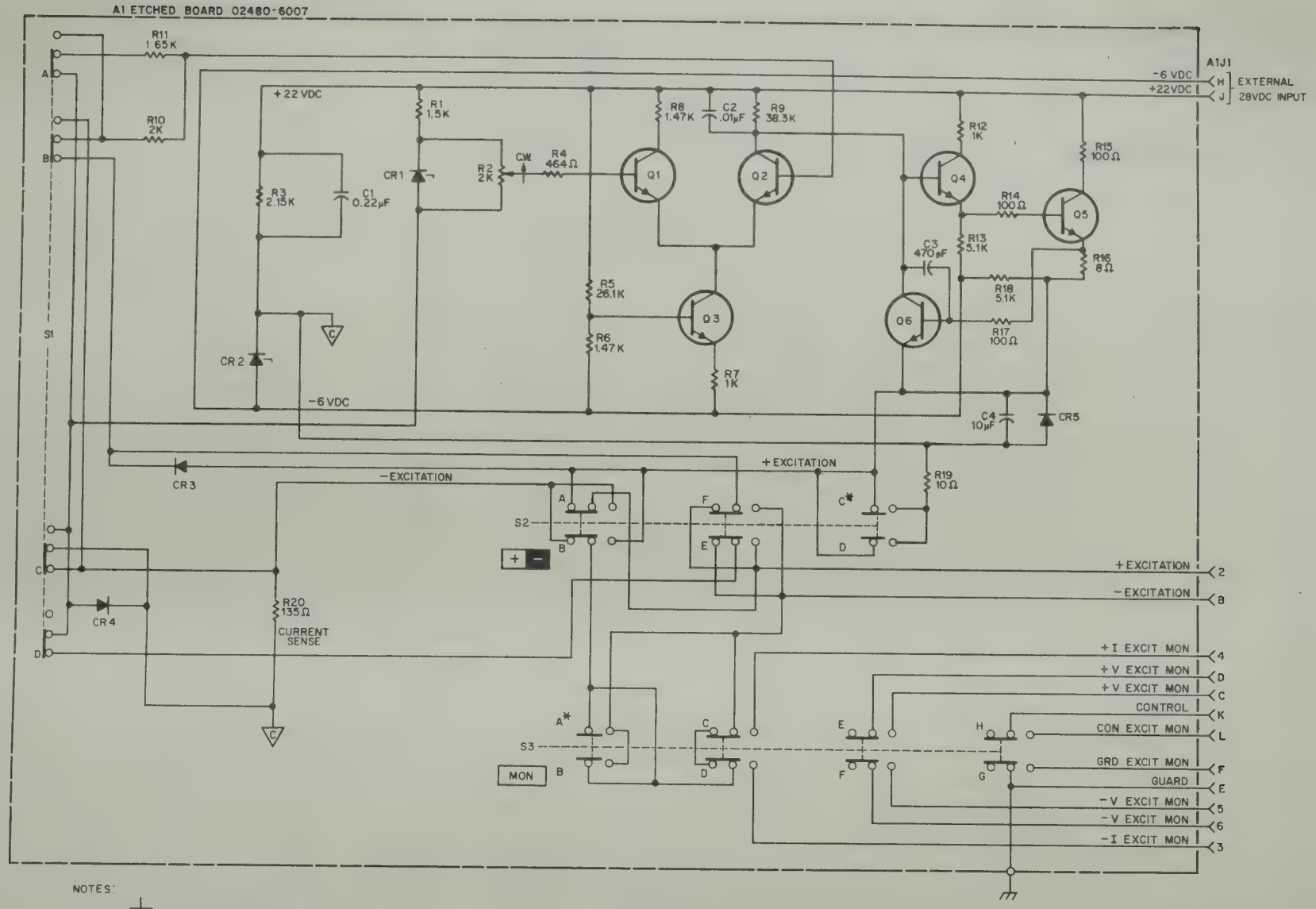


* -EXTERNAL EXCITATION INPUT
* +EXTERNAL EXCITATION INPUT
CAL. POWER STEP 6
GUARD SIGNAL MONITOR
+CAL. POWER
+V. SIGNAL MONITOR
CAL. POWER STEP 7
-V. SIGNAL MONITOR
CAL. POWER STEP 1
CONTROL SIGNAL MONITOR
CAL. POWER COMMON
CAL. POWER STEP 5
CONTROL EXCITATION MONITOR
CAL. POWER STEP 4
GUARD EXCITATION MONITOR
CAL. POWER STEP 3
+V. EXCITATION MONITOR
CAL POWER STEP 2
-V. EXCITATION MONITOR
-I EXCITATION MONITOR
+I EXCITATION MONITOR

C12521-6008

* PIN NOS. SHOWN ARE THOSE OF COMBINING CASE CONNECTOR XA11.

		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: DECIMALS± FRACTIONS± ANGLES± ALL SURFACES√	DRAWN BY	DATE	SCHEMATIC CONTROL BOARD
			CHECKED BY		
		MATERIAL	ENG APPD		
	12521A	STK NO	PROJ APPD		
NEXT ASSY	USED ON	FINISH OR TREATMENT	MFG APPD		
APPLICATION			SCALE		HEWLETT PACKARD DYMEC DIVISION 395 Page Mill Road Palo Alto California 94306
					C 12521 - 6008 - 2
					CODE 04404 SHEET 1 OF 1



NOTES:

C CIRCUIT REFERENCE POINT FOR VOLTAGES SHOWN

INSTRUMENT CASE (GUARD)

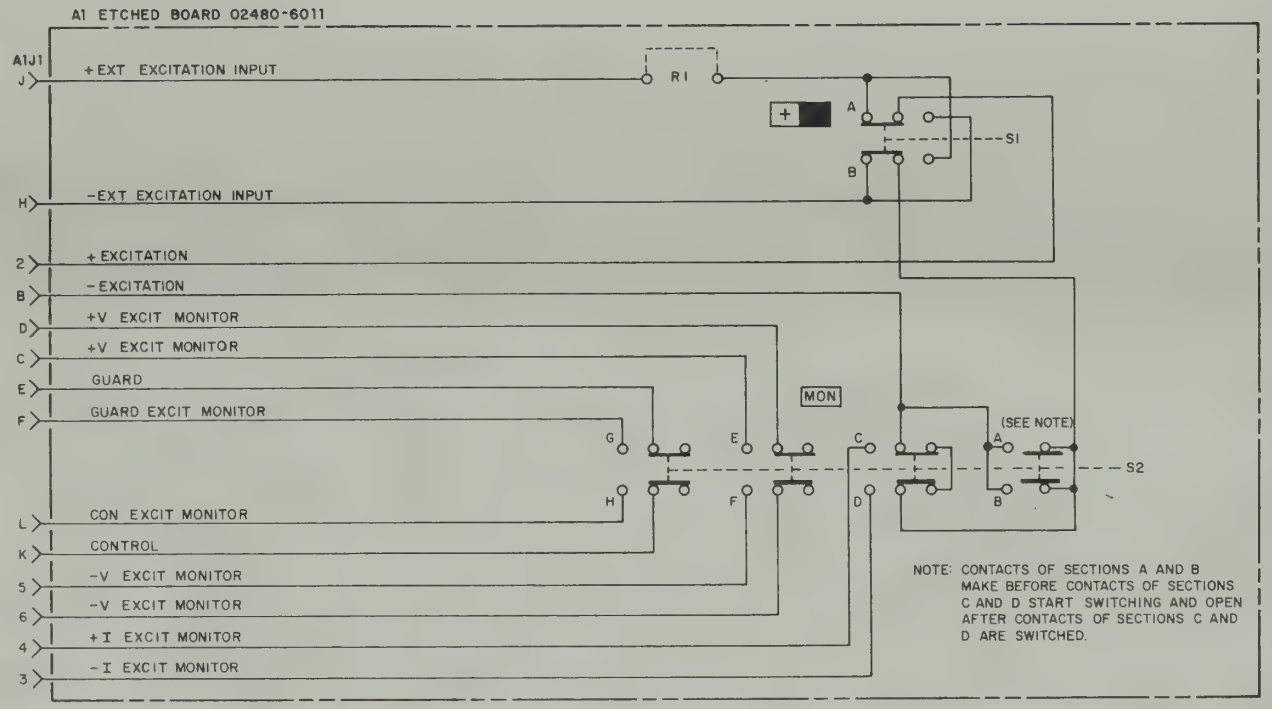
SWITCH POSITIONS
S1 CONSTANT VOLTAGE
S2 +VE
S3 MONITOR OFF

*DURING SWITCHING, SECTIONS C AND D OF S2 CLOSE FIRST AND DO NOT OPEN UNTIL SWITCHING OF OTHER SECTIONS IS COMPLETE. SECTIONS A AND B OF S3 ARE MECHANICALLY TIMED TO BE CLOSED DURING SWITCHING OF ITS OTHER SECTIONS.

C-02480-6009-S

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: DECIMALS± FRACTIONS± ANGLES± ALL SURFACES✓	DRAWN BY GE.	DATE 4-22-67	PREFIX 747-
MATERIAL	CHECKED BY Sem	7-16-67	HP-2480C EXCITATION COUPLER
STK NO	ENG APPD		HEWLETT PACKARD DYMEC DIVISION
FINISH OR TREATMENT	PROJ APPD		395 Page Mill Road Palo Alto California 94306
	MFG APPD		C-02480-6009-2
	SCALE		CODE 04404 SHEET

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL



C02480-6011-S

PREFIX 747-

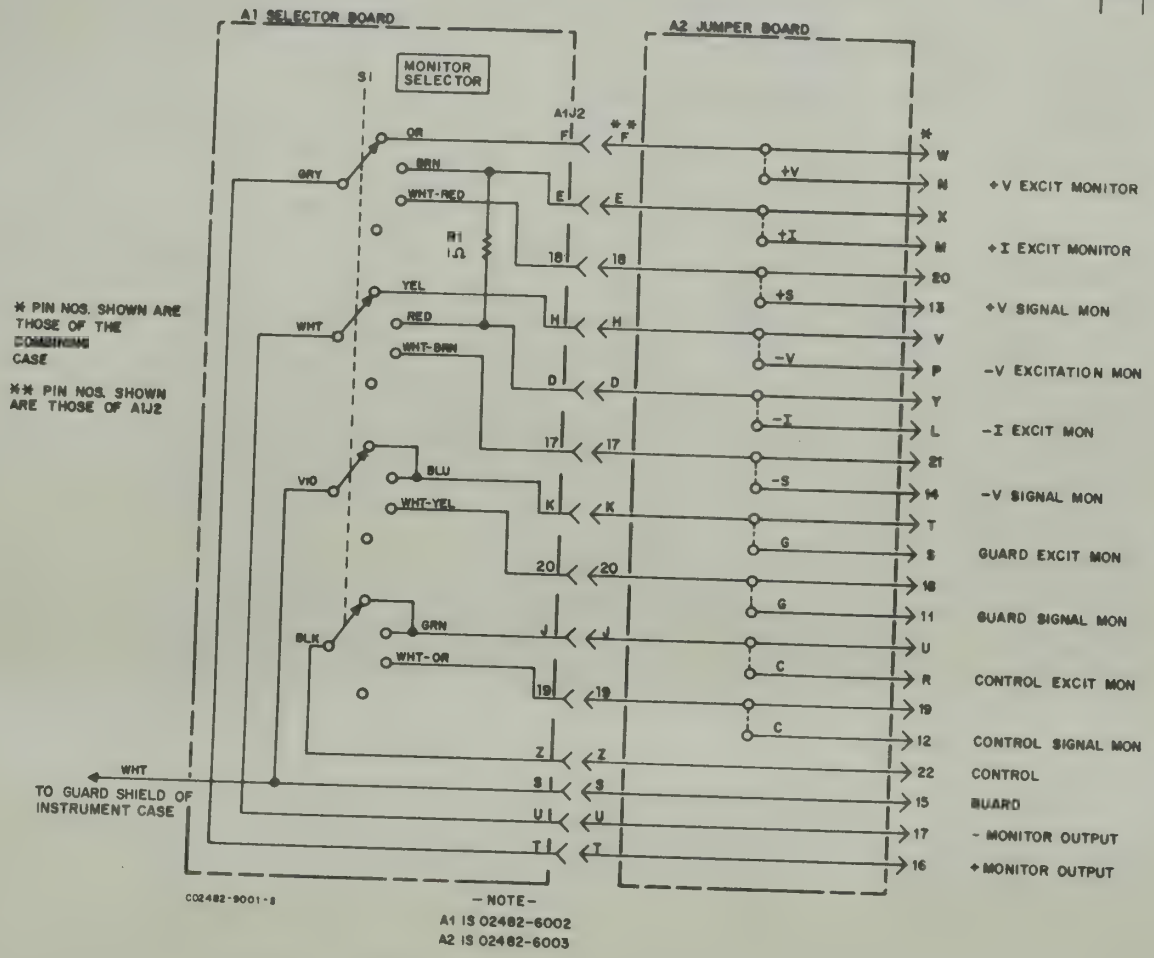
		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: DECIMALS± FRACTIONS± ANGLES± ALL SURFACES√	DRAWN BY E.	DATE 4-1-70	EXCITATION COUPLER
			CHECKED BY		
		MATERIAL	ENG APPD		
		STK NO	PROJ APPD		SCHEMATIC 2480K
NEXT ASSY	USED ON	FINISH OR TREATMENT	MFG APPD		
APPLICATION			SCALE		

HEWLETT PACKARD DYMEC DIVISION
395 Page Mill Road Palo Alto California 94306

C02480-6011-2

CODE 04404 SHEET 1-1

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL



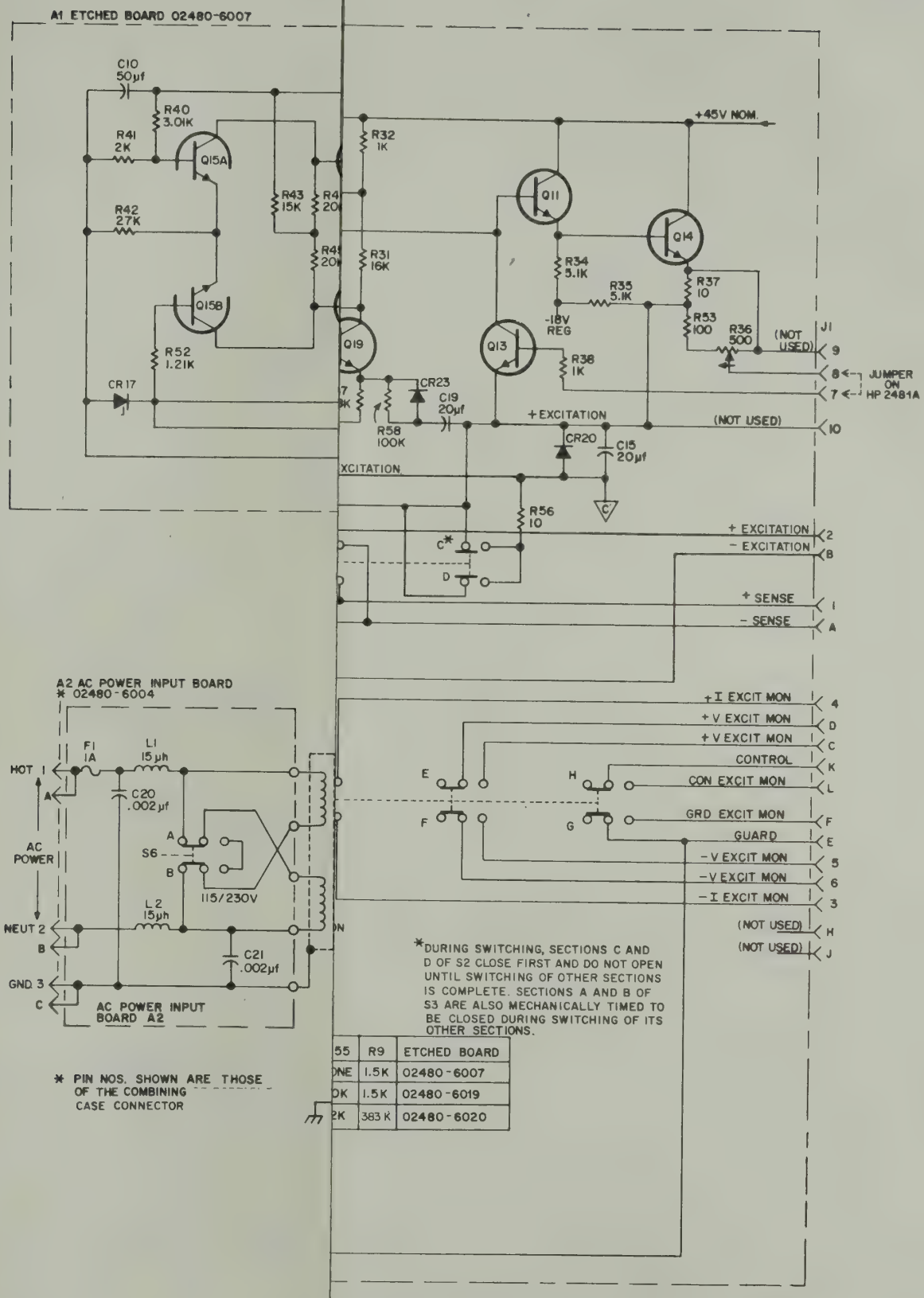
* PIN NOS. SHOWN ARE THOSE OF THE COMBINING CASE

** PIN NOS. SHOWN ARE THOSE OF A1J2

C02482-9001-S

– NOTE –
A1 IS 02482-6002
A2 IS 02482-6003

NEXT ASSY	USED ON	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: DECIMALS ± FRACTIONS ± ANGLES ± ALL SURFACES √	DRAWN BY	DATE	PREFIX 747–
APPLICATION		MATERIAL	CHECKED BY		MONITOR FUNCTION SELECTOR HP-2482N
		STK. NO	ENG APPD		HEWLETT PACKARD / DYMEC DIVISION
		FINISH OR TREATMENT	PROJ APPD		395 Page Mill Road, Palo Alto, California 94306
			MFG APPD		C 02482-9001-1
			SCALE		CODE 04404 SHEET



55	R9	ETCHED BOARD
ONE	1.5K	02480-6007
OK	1.5K	02480-6019
2K	383K	02480-6020

PREFIX 747-

DRAWN BY	DATE
E Hale	3-7-67
CHECKED BY	
ENG APPD	
PROJ APPD	
MFG APPD	

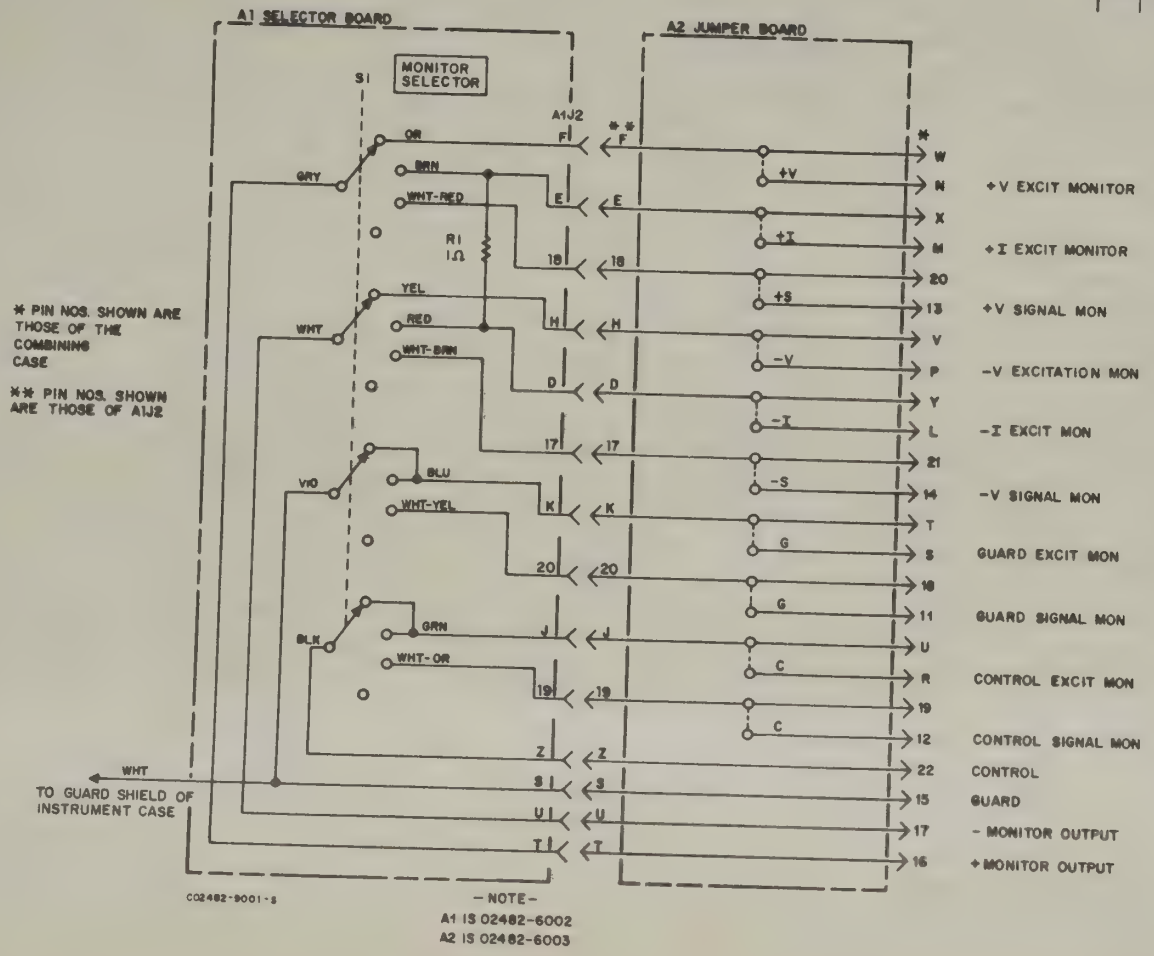
HP2480A
D.C. EXCITATION SOURCE
SCHEMATIC

HEWLETT PACKARD DYMEC DIVISION
395 Page Mill Road Palo Alto California 94306

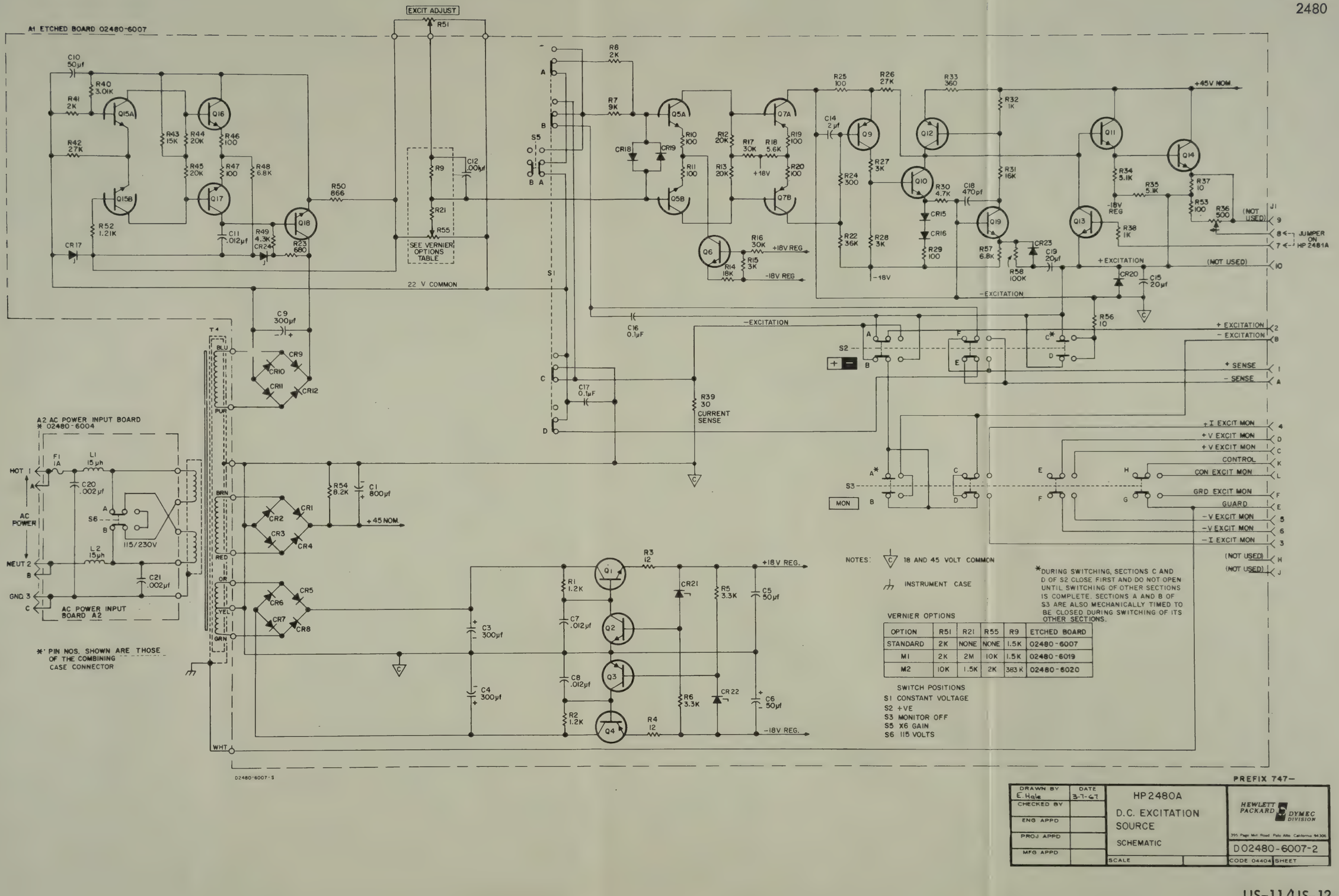
D02480-6007-2

SCALE | CODE 04404 | SHEET

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL



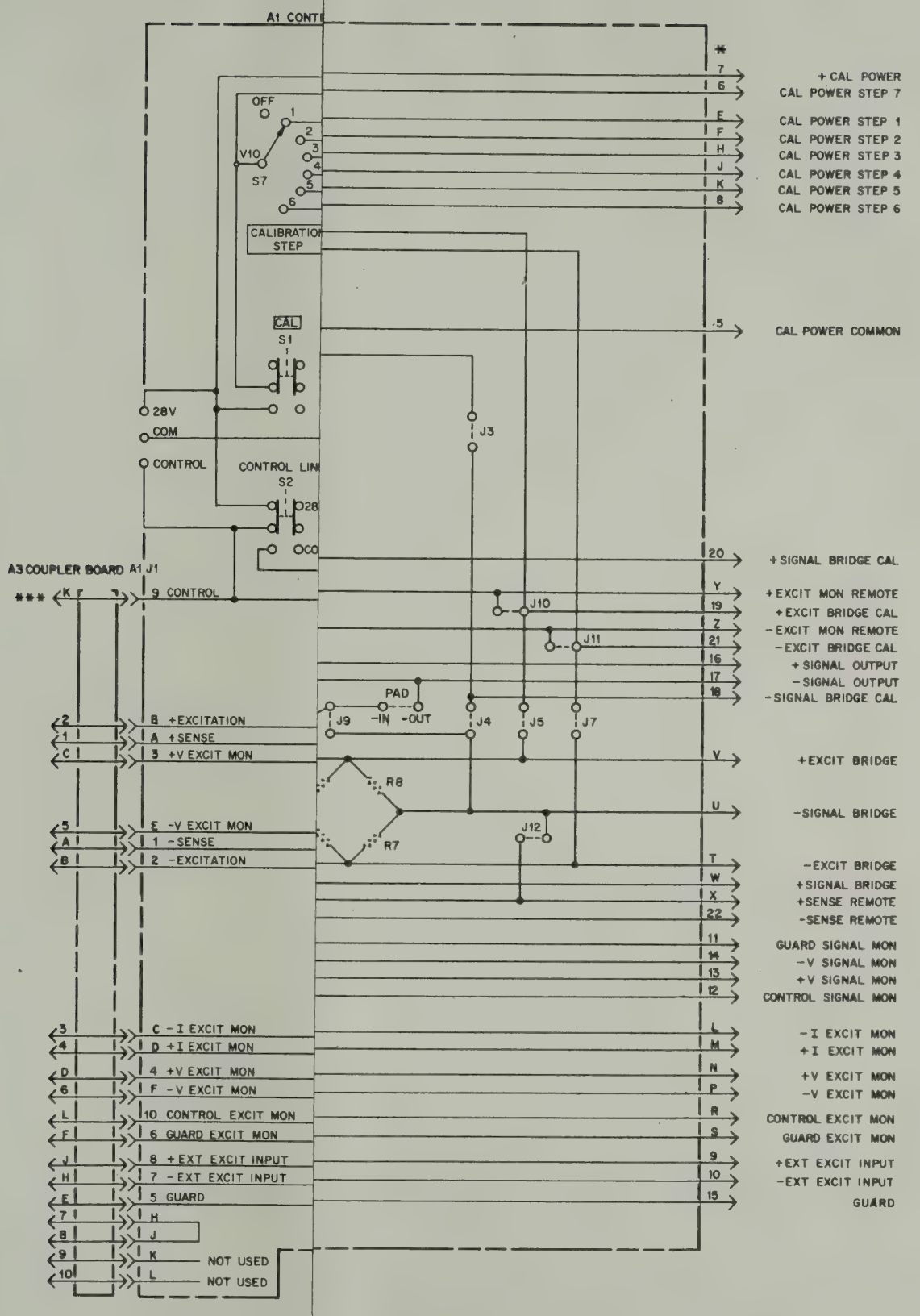
		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: DECIMALS± FRACTIONS± ANGLES± ALL SURFACES√	DRAWN BY	DATE	PREFIX 747-
		MATERIAL	CHECKED BY		MONITOR FUNCTION SELECTOR HP-2482N
			ENG APPD		HEWLETT PACKARD DYMEC DIVISION
		TK. NO	PROJ APPD		395 Page Mill Road, Palo Alto California 94306
NEXT ASSY	USED ON	FINISH OR TREATMENT	MFG APPD		C 02482-9001-1
APPLICATION			SCALE		CODE 04404 SHEET



OPTION	R51	R21	R55	R9	ETCHED BOARD
STANDARD	2K	NONE	NONE	1.5K	02480-6007
M1	2K	2M	10K	1.5K	02480-6019
M2	10K	1.5K	2K	383K	02480-6020

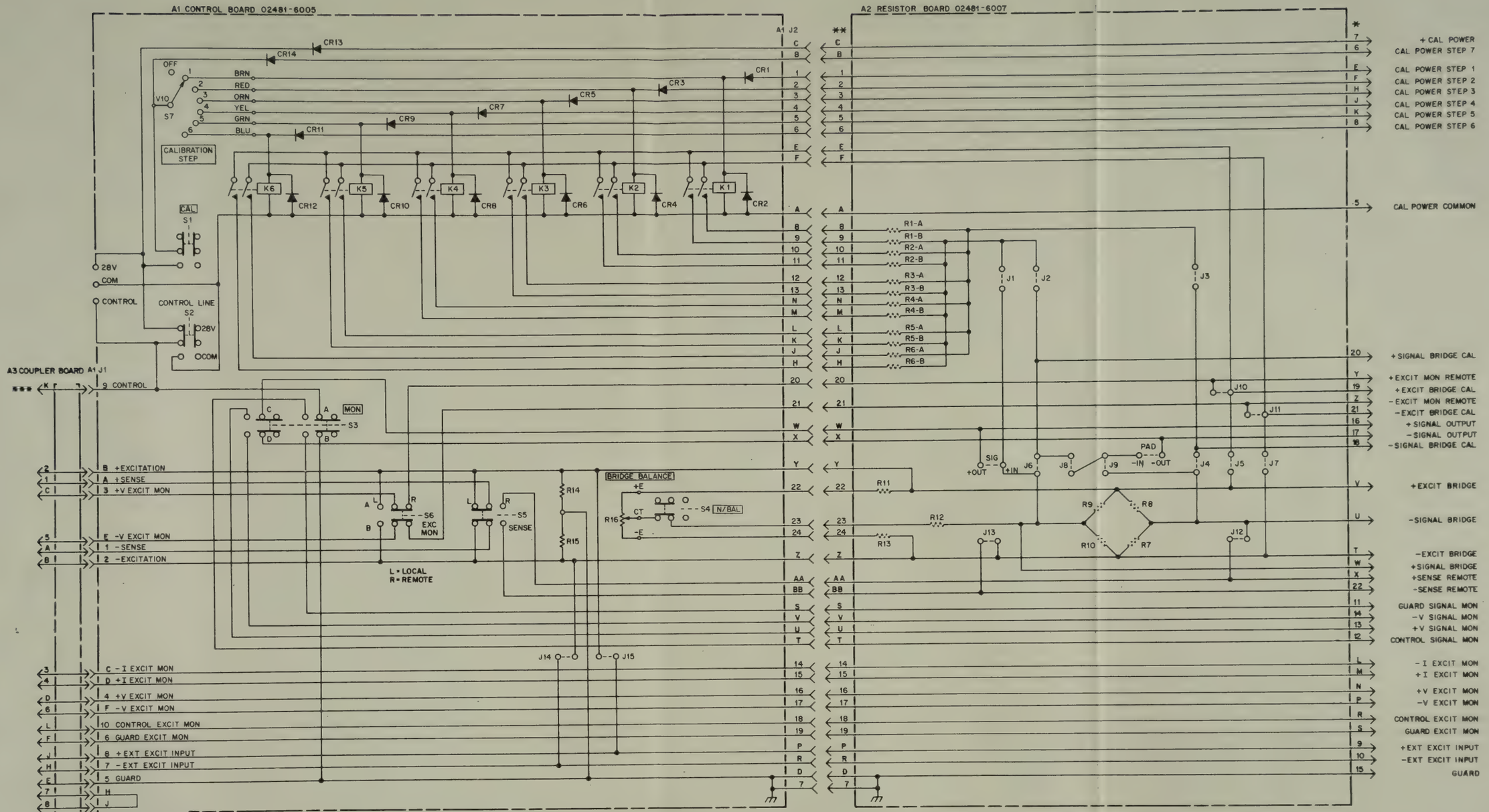
PREFIX 747-

DRAWN BY E. Hale	DATE 3-1-67	HP 2480A D.C. EXCITATION SOURCE SCHEMATIC	HEWLETT PACKARD / DYMEC DIVISION 395 Page Mill Road Palo Alto California 94306
CHECKED BY			D02480-6007-2
ENG APPD			
PROJ APPD			
MFG APPD		SCALE	CODE 04404 SHEET



PREFIX 747-

DRAWN BY C. J.	DATE 6/66	HP-2481A RESISTANCE BRIDGE SCHEMATIC	HEWLETT PACKARD DYMEC DIVISION
CHECKED BY			395 Page Mill Road, Palo Alto, California 94306
ENG APPD			D02481-9001-1
PROJ APPD			
MFG APPD		SCALE	CODE 04404 SHEET 1



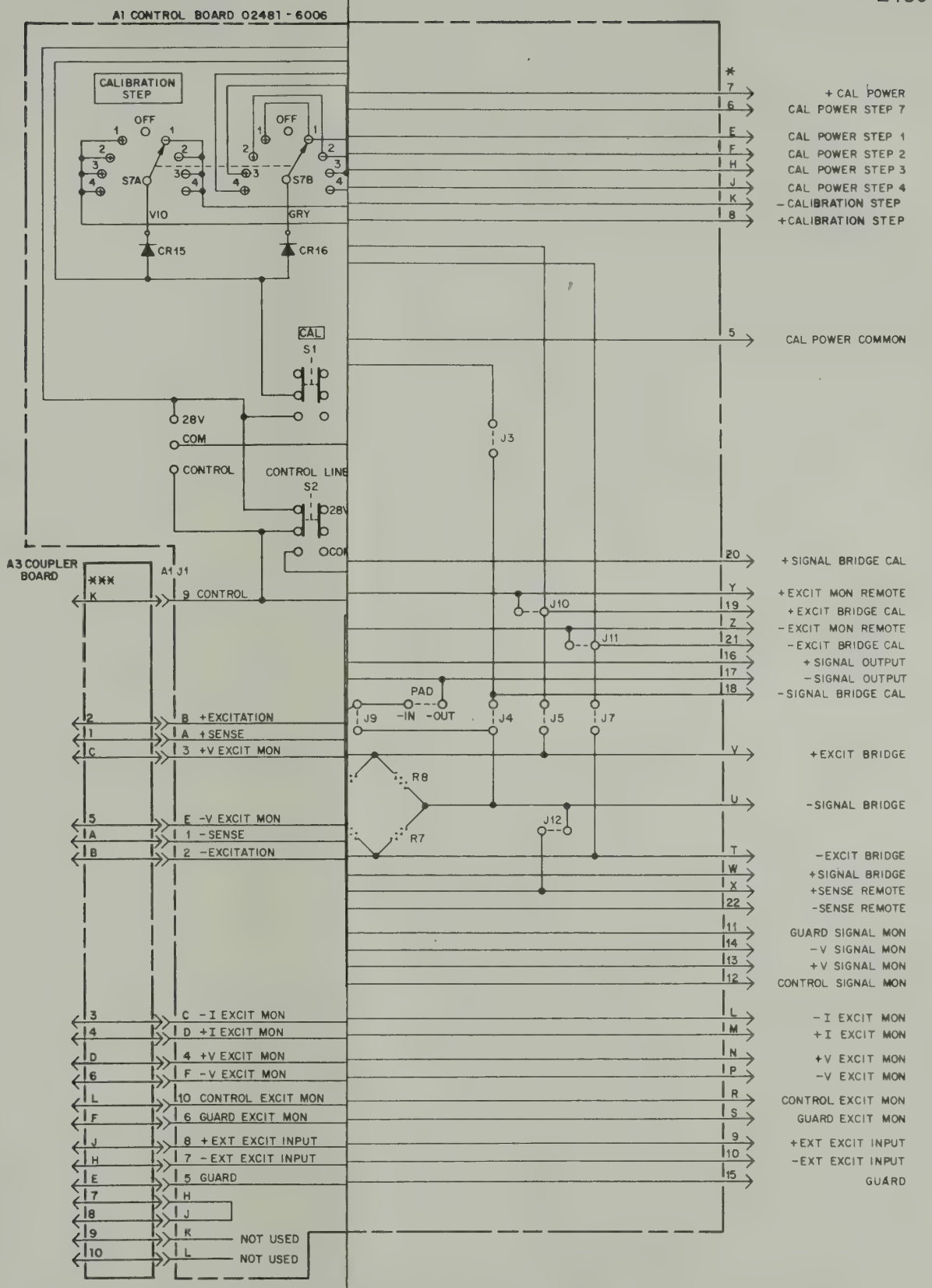
D02481-9001-S

NOTE: THIS SCHEMATIC REPRESENTS THE hp 2481A M5/M6, THE MOST COMPREHENSIVE VERSION OF THE INSTRUMENT. THE TABLE TO THE RIGHT PROVIDES DETAILS ON THE OTHER VERSIONS
* PIN NOS. SHOWN ARE THOSE OF THE COMBINING CASE CONNECTOR
** PIN NOS. SHOWN ARE THOSE OF THE CONTROL BOARD CONNECTOR A1J2.
*** PIN NOS. SHOWN ARE THOSE OF THE EXCITATION SOURCE CONNECTOR A1J1.

INSTRUMENT	SCHEMATIC CHANGES
STANDARD	DELETE S7 AND K2 THRU K6
M1	DELETE S7 AND K3 THRU K6
M2	DELETE S7 AND K4 THRU K6
M3	DELETE S7 K5 AND K6
M4	DELETE S7 AND K6
M5	DELETE S7
M6	DELETE K2 THRU K6

PREFIX 747-

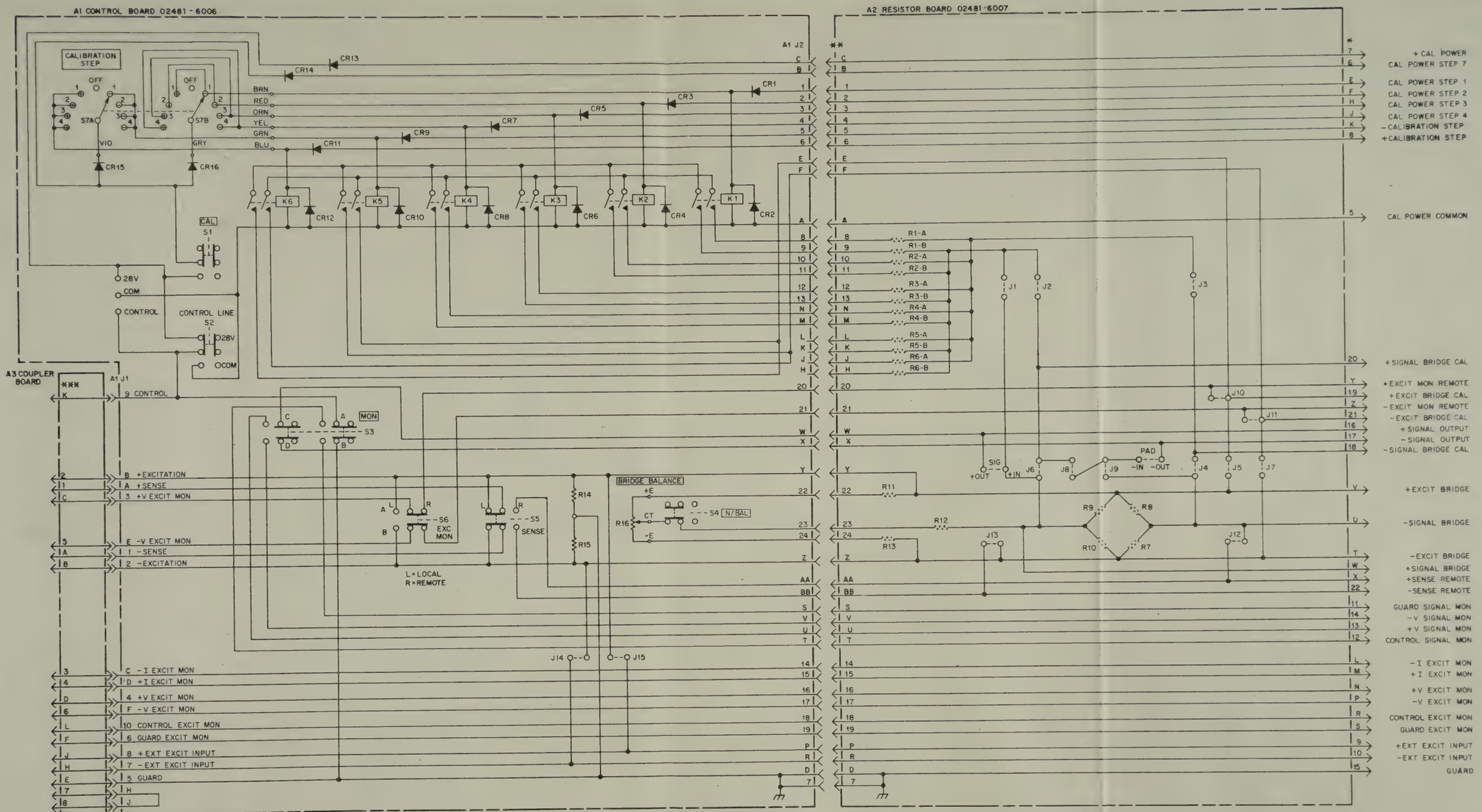
DRAWN BY C. J.	DATE 8/86	HP-2481A RESISTANCE BRIDGE SCHEMATIC	HEWLETT PACKARD DYMEC DIVISION 395 Page Mill Road Palo Alto California 94306
CHECKED BY			D02481-9001-1
ENG APPD			CODE 04404 SHEET
PROJ APPD		SCALE	
MFG APPD			



D02481-9002-S

PREFIX 747-

DRAWN BY C. J.	DATE 8/66	HP-2481A M7,8 RESISTANCE BRIDGE SCHEMATIC	HEWLETT PACKARD DYMEC DIVISION 395 Page Mill Road Palo Alto California 94306
CHECKED BY			D02481-9002-1
ENG APPD			
PROJ APPD			
MFG APPD		SCALE	CODE 04404 SHEET



D02481-9002-S

NOTE: THIS SCHEMATIC REPRESENTS THE hp 2481A M7 WITH M3 AND M8. THE MOST COMPREHENSIVE VERSION OF THE INSTRUMENT. THE TABLE TO THE RIGHT PROVIDES DETAILS ON THE OTHER VERSIONS.

* PIN NOS. SHOWN ARE THOSE OF THE COMBINING CASE CONNECTOR.

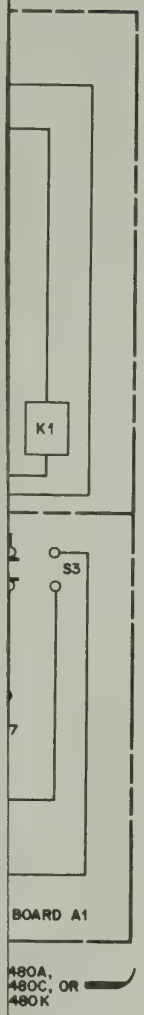
** PIN NOS. SHOWN ARE THOSE OF THE CONTROL BOARD CONNECTOR A1J2.

*** PIN NOS. SHOWN ARE THOSE OF THE EXCITATION SOURCE CONNECTOR A1J1.

INSTRUMENT	SCHEMATIC CHANGES
M7	DELETE S7 AND K2 THRU K4
M7, M1	DELETE S7, K3, K4
M7, M2	DELETE S7 AND K4
M7, M3	DELETE S7
M7, M8	DELETE K2 THRU K4

PREFIX 747-

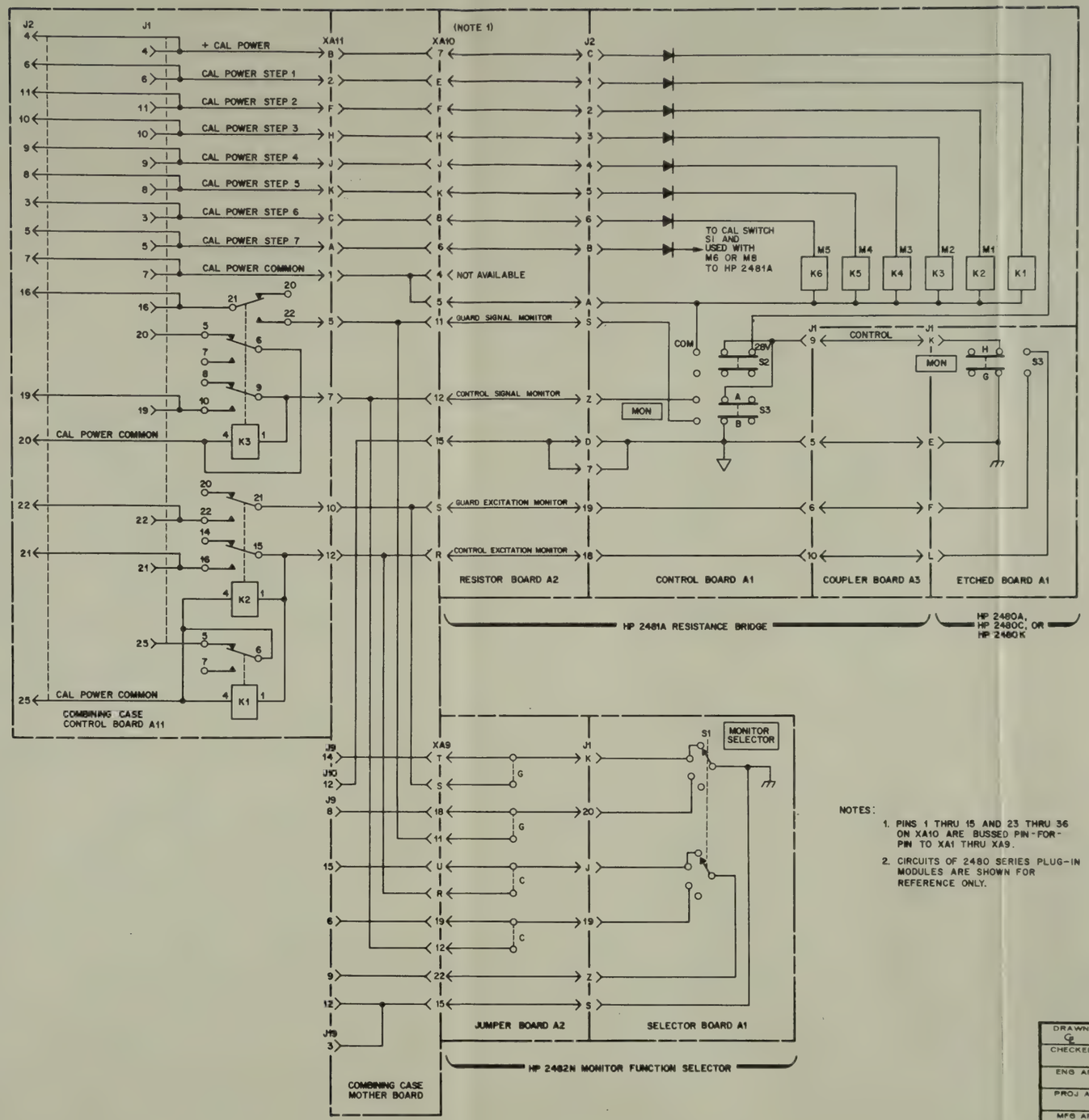
DRAWN BY C. J.	DATE 8/66	HP-2481A M7,8 RESISTANCE BRIDGE SCHEMATIC	HEWLETT PACKARD DYMEC DIVISION
CHECKED BY			
ENG APPD			
PROJ APPD			D02481-9002-1
MFG APPD		SCALE	CODE 04404 SHEET



23 THRU 36
D PIN-FOR-
A9.

ERIES PLUG-IN
N FOR

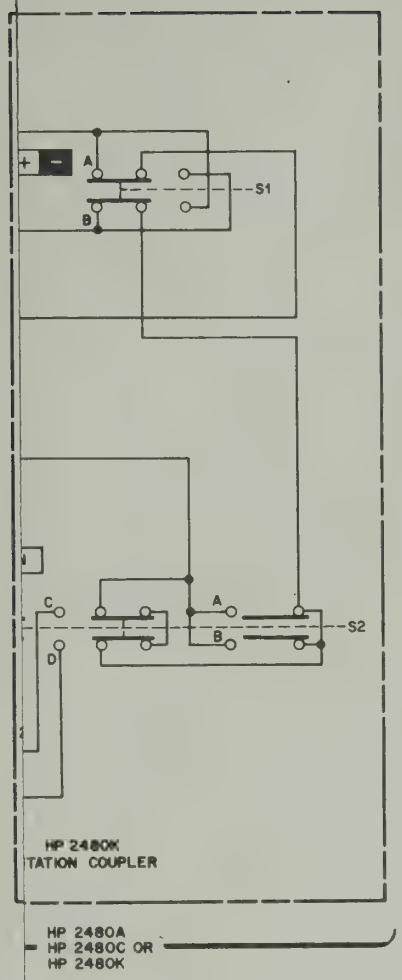
DRAWN BY CE	DATE	HP 2480 SERIES (CONTROL AND GUARD CIRCUITS) INTERCONNECTION DIAGRAM	HEWLETT PACKARD DYMEC DIVISION 395 Page Mill Road Palo Alto California 94306
CHECKED BY			D12521-9008-1
ENG APPD			
PROJ APPD			
MFG APPD		SCALE	CODE 04404 SHEET 1-3



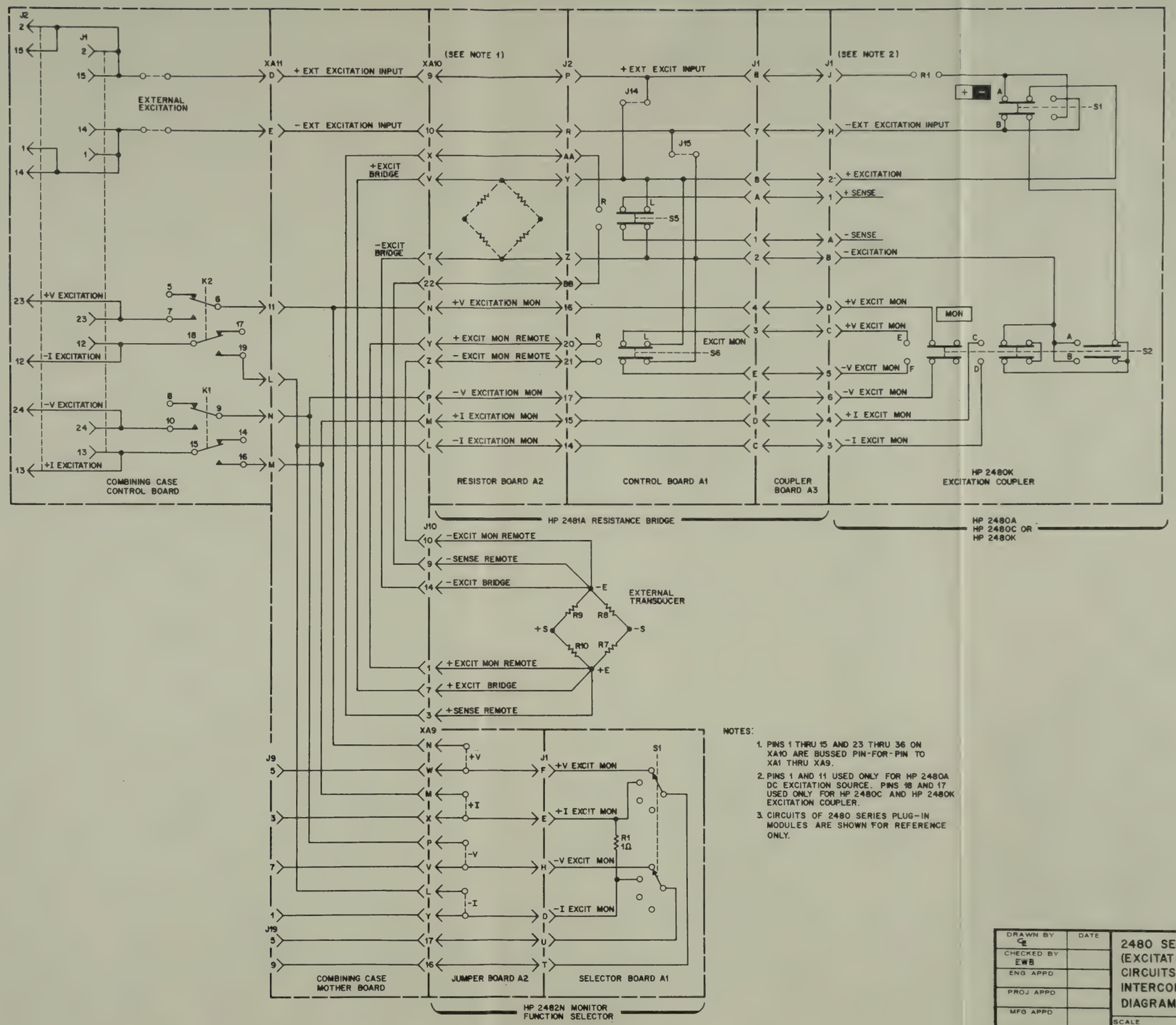
NOTES:

1. PINS 1 THRU 15 AND 23 THRU 36 ON XA10 ARE BUSSED PIN-FOR-PIN TO XA1 THRU XA9.
2. CIRCUITS OF 2480 SERIES PLUG-IN MODULES ARE SHOWN FOR REFERENCE ONLY.

DRAWN BY	DATE	HP 2480 SERIES (CONTROL AND GUARD CIRCUITS) INTERCONNECTION DIAGRAM	HEWLETT PACKARD DYMEC DIVISION 395 Page Mill Road Palo Alto California 94306
CHECKED BY			D12521-9008-1
ENG APPD			
PROJ APPD			
MFG APPD		SCALE	CODE 04404 SHEET 1-3



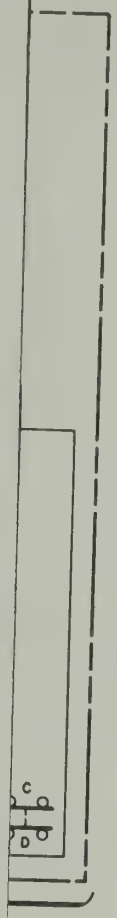
DRAWN BY	DATE	2480 SERIES (EXCITATION CIRCUITS) INTERCONNECTION DIAGRAM	HEWLETT PACKARD DYMEC DIVISION
CE			395 Page Mill Road Palo Alto California 94306
CHECKED BY EWB			D12521-9008-2
ENG APPD			
PROJ APPD			
MFG APPD		SCALE	CODE 04404 SHEET 2-3



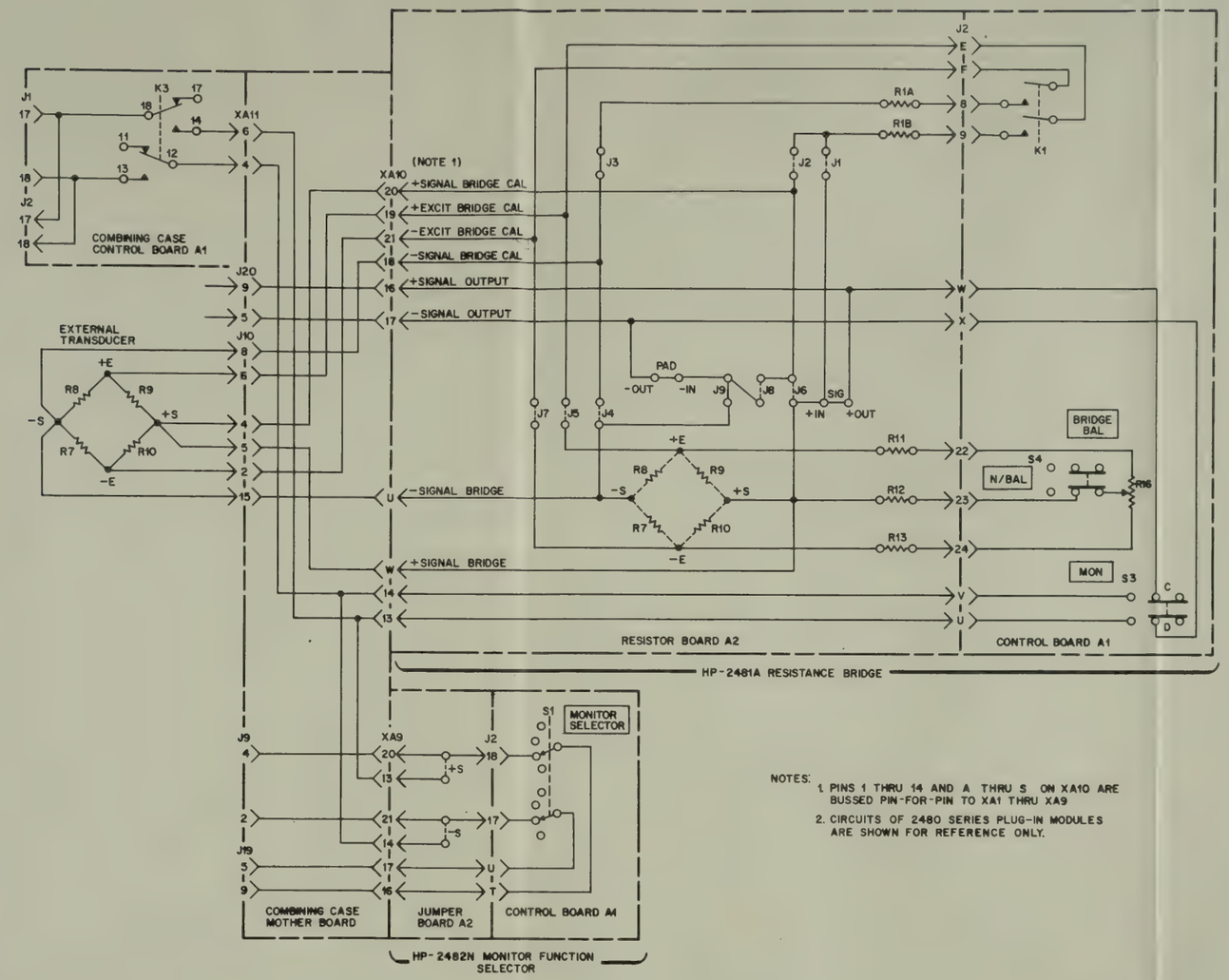
NOTES:

1. PINS 1 THRU 15 AND 23 THRU 36 ON XA10 ARE BUSSED PIN-FOR-PIN TO XA1 THRU XA9.
2. PINS 1 AND 11 USED ONLY FOR HP 2480A DC EXCITATION SOURCE. PINS 18 AND 17 USED ONLY FOR HP 2480C AND HP 2480K EXCITATION COUPLER.
3. CIRCUITS OF 2480 SERIES PLUG-IN MODULES ARE SHOWN FOR REFERENCE ONLY.

DRAWN BY CE	DATE	2480 SERIES (EXCITATION CIRCUITS) INTERCONNECTION DIAGRAM	HEWLETT PACKARD DYMEC DIVISION 395 Page Mill Road Palo Alto California 94306
CHECKED BY EWB			D12521-9008-2
ENG APPD			
PROJ APPD			
MFG APPD		SCALE	CODE 04404 SHEET 2-3



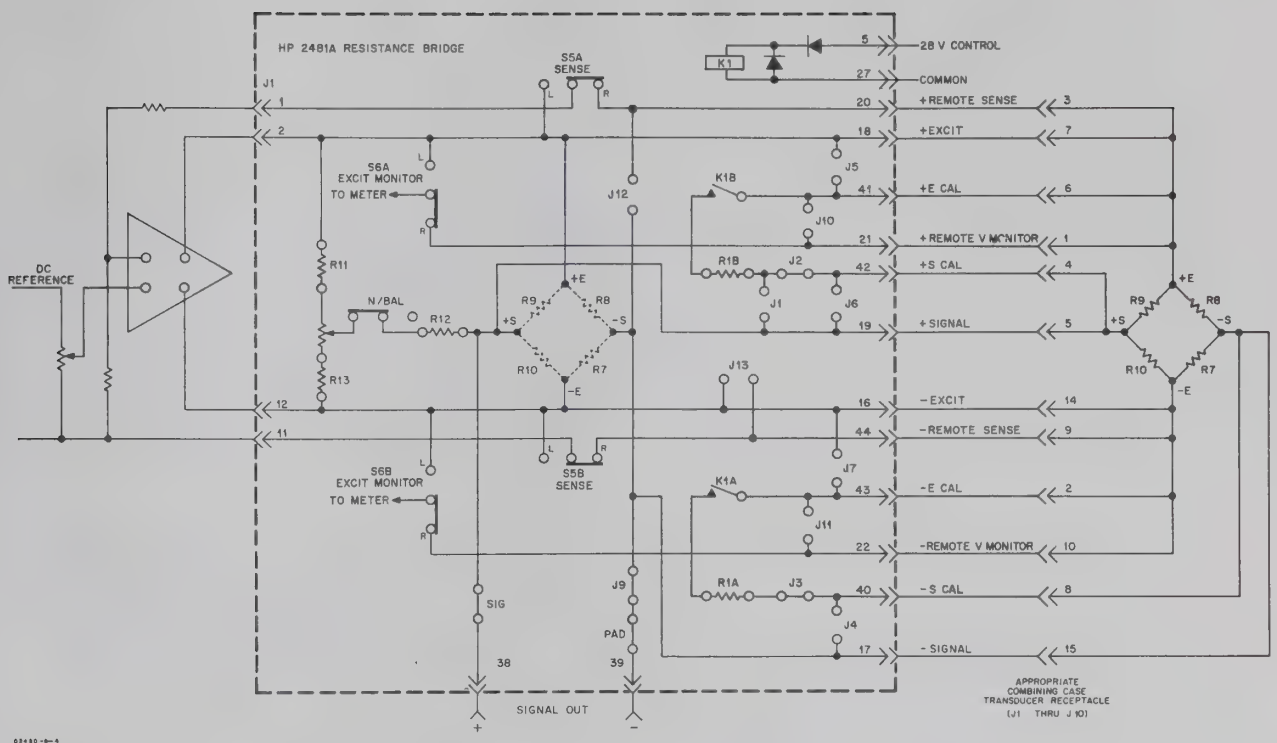
DRAWN BY	DATE	2480 SERIES (SIGNAL CIRCUITS) INTERCONNECTION DIAGRAM	HEWLETT PACKARD DYMEC DIVISION
CHECKED BY			395 Page Mill Road Palo Alto California 94306
ENG APPD			D12521-9008-3
PROJ APPD			
MFG APPD		SCALE	CODE 04404 SHEET 3-3



NOTES:

1. PINS 1 THRU 14 AND A THRU S ON XA10 ARE BUSSED PIN-FOR-PIN TO XA1 THRU XA9
2. CIRCUITS OF 2480 SERIES PLUG-IN MODULES ARE SHOWN FOR REFERENCE ONLY.

DRAWN BY	DATE	2480 SERIES (SIGNAL CIRCUITS) INTERCONNECTION DIAGRAM	HEWLETT PACKARD DYMEC DIVISION 395 Page Mill Road Palo Alto California 94306
CHECKED BY			D12521-9008-3
ENG APPD			
PROJ APPD			
MFG APPD		SCALE	CODE 04404 SHEET 3-3



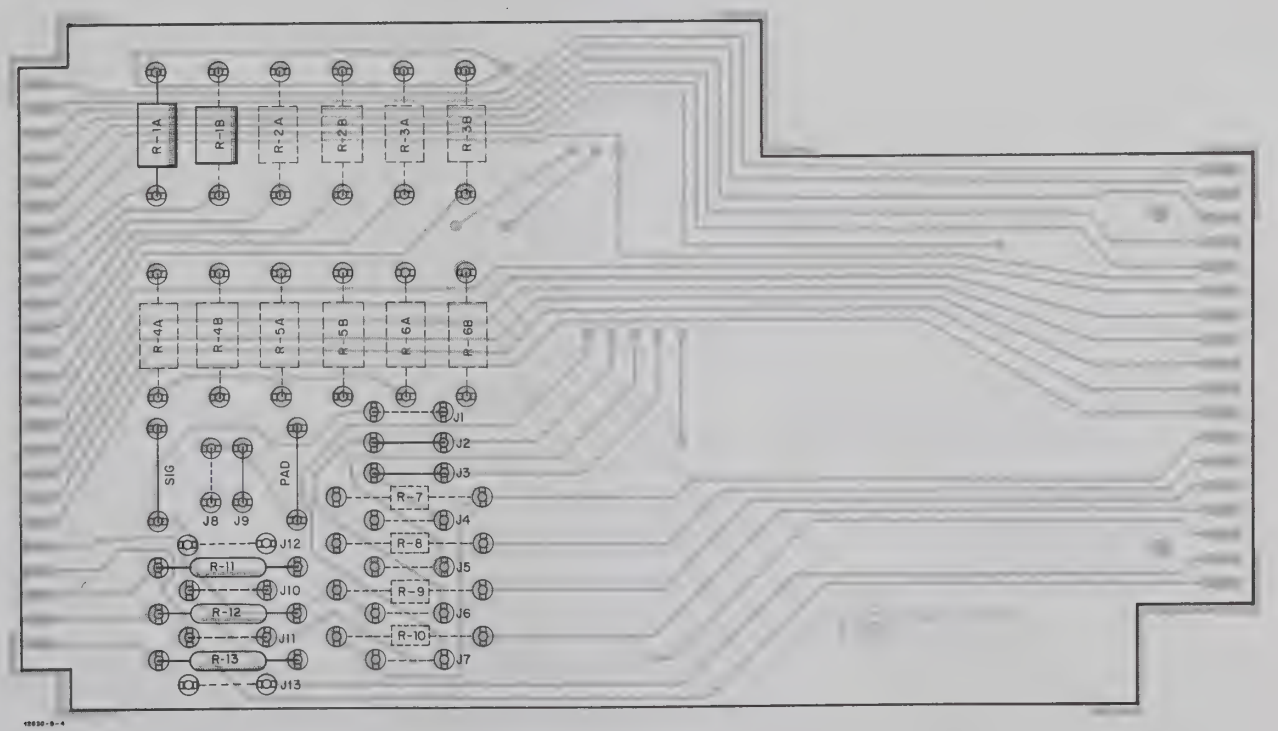


Figure 2-6. Four Active-Arm, Constant Voltage Mode: Circuit and Resistor Board Loading

Table 2-1 HP-2480A DC Excitation Source Controls (Cont'd)

Item	Control	Function
3	EXCIT ADJ Control	A 10-turn potentiometer which provides adjustment of the excitation source output voltage. In all versions of the HP-2480A DC Excitation Source except the M2 version it provides full span adjustment. In the M2 version a screwdriver adjustment potentiometer gives the full span adjustment and the EXCIT ADJ control provides fine adjustment.
4	POLARITY REVERSAL + or - Switch	Changes the polarity of the excitation applied to the transducer. When the switch is depressed the bridge polarities (+E and -E) are as shown in Figures 2-3 through 2-6 and when extended +E and -E are reversed.
5	MON Switch	The MON switch enables the excitation voltage or current to be measured by an external meter. When depressed the MON switch connects the voltage or current component, as determined by the HP-2482N Monitor Function Selector, to an external meter. The MON switch includes contacts for switching the transducer guard line to the external meter (reducing common mode effects) and contacts that provide a closure to +cal power or the power common (as selected by item 6 of table 2-2) for external use as a control line. In a combining case, this control line prevents simultaneous operation of a signal monitoring function in more than one combining case at a time.
6	Vernier Control	Only provided with the M1 and M2 versions of the HP-2480A DC Excitation Source. In the M1 version the vernier permits fine control of the excitation source output level. In the M2 version the vernier provides full span control of the output level and the EXCIT ADJ control provides the fine control.

Table 2-2 HP-2481A Resistance Bridge Controls and Jumpers*

Item	Control	Function
1	CAL Switch	The CAL switch energizes a relay which switches in the bridge calibration resistor mounted on the resistor board. With the M6 version of the HP-2481A that has the CALIBRATION STEP control (Item 5) the CAL switch energizes the particular relay selected by the CALIBRATION STEP control. Calibration power at 24 vdc must be present for CAL switch operation.
2	MON Switch	The MON switch connects the bridge output signal to the signal monitoring device. The MON switch includes contacts for switching the transducer guard line to the external meter(reducing common mode effects) and contacts that provide a closure to +cal power or the power common (as selected by item 6) for external use as a control line. In a combining case, this control line prevents simultaneous operation of a signal monitoring function in more than one combining case at a time.
3	N/BAL Switch	The N/BAL pushbutton enables the balance potentiometer (Item 4) to be switched out of circuit. This unique feature of the HP-2481A allows a transducer preload signal to be detected and measured separately from the off-center output of the balance circuits.
4	BRIDGE BAL Control	The BRIDGE BAL potentiometer provides high-resolution adjustment of bridge balance.
5	CALIBRATION STEP Switch	Only provided with the M6 version of HP-2481A Resistance Bridge. The switch selects one of up to six relays, which can switch in the different pairs of calibration resistors mounted on the resistor board.

*Refer to listing in paragraph 3-9 for Function of jumpers of control and resistor boards.

Table 2-2 HP-2481A Resistance Bridge Controls and Jumpers (Cont'd.)

Item	Control	Function
6	CONTROL LINE 28V or COM	Selects +cal power or the power return for connection to the MON switch of the 2481A or 2480A.
7	SENSE Switch	Permits the HP-2480A DC Excitation Source "Sense" connection to monitor the bridge excitation voltage remotely at the transducer or locally at the bridge completion resistors, mounted on the resistor board. This switch is inoperative in the constant current mode.
8	EXC MON Switch	Permits the bridge excitation voltage to be monitored remotely at the transducer or locally at the bridge completion resistors.

Table 2-3 HP-2480K Excitation Coupler Controls

Item	Control	Function
1	+ or - Switch	Function same as item 4 of Table 2-1.
2	MON Switch	Function same as item of Table 2-1.

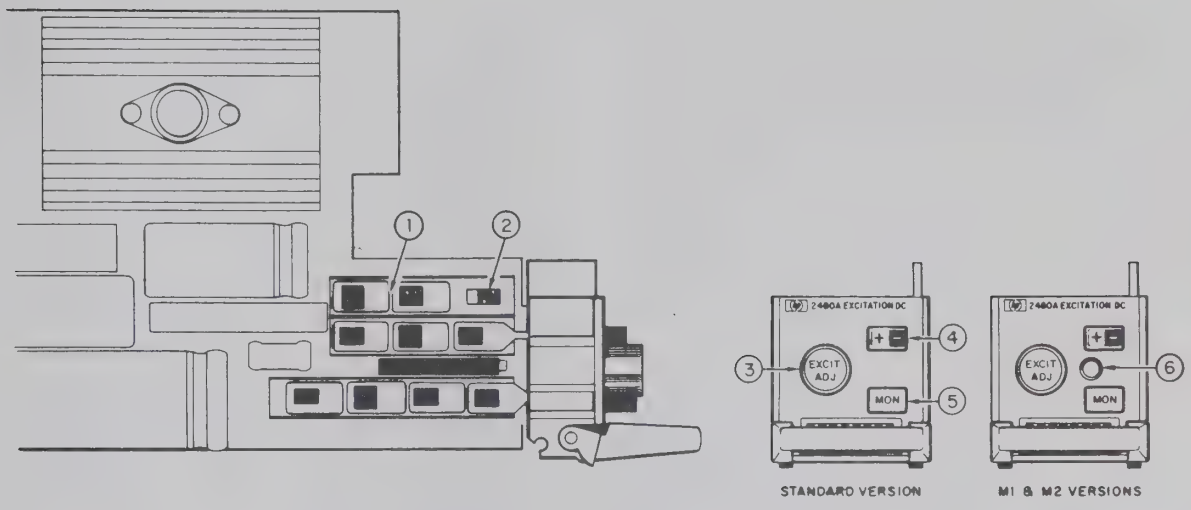


FIGURE 2-7 HP-2480A DC EXCITATION SOURCE CONTROLS

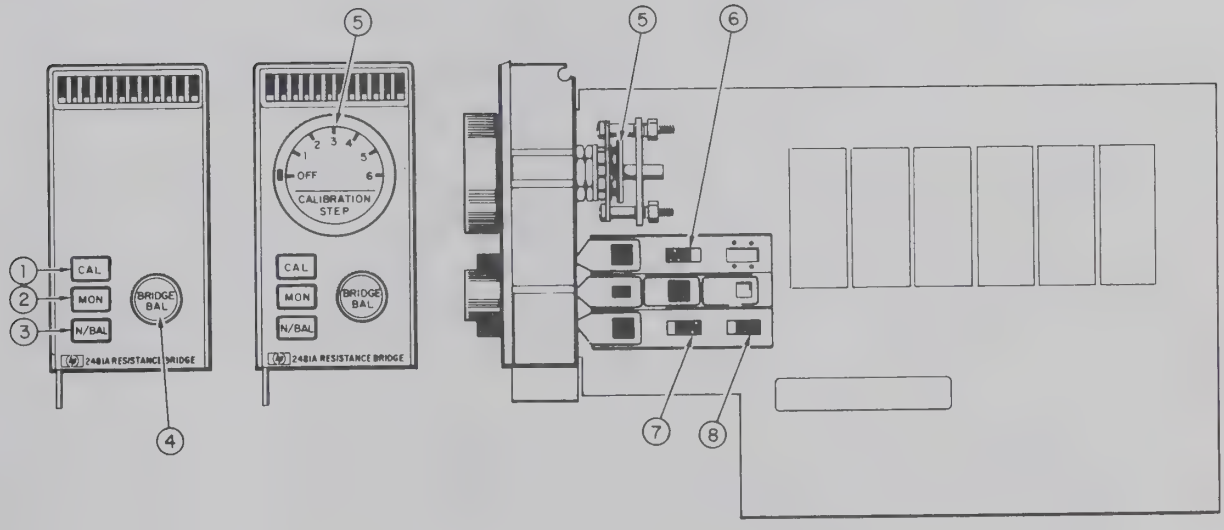


FIGURE 2-8 HP-2481A RESISTANCE BRIDGE CONTROLS

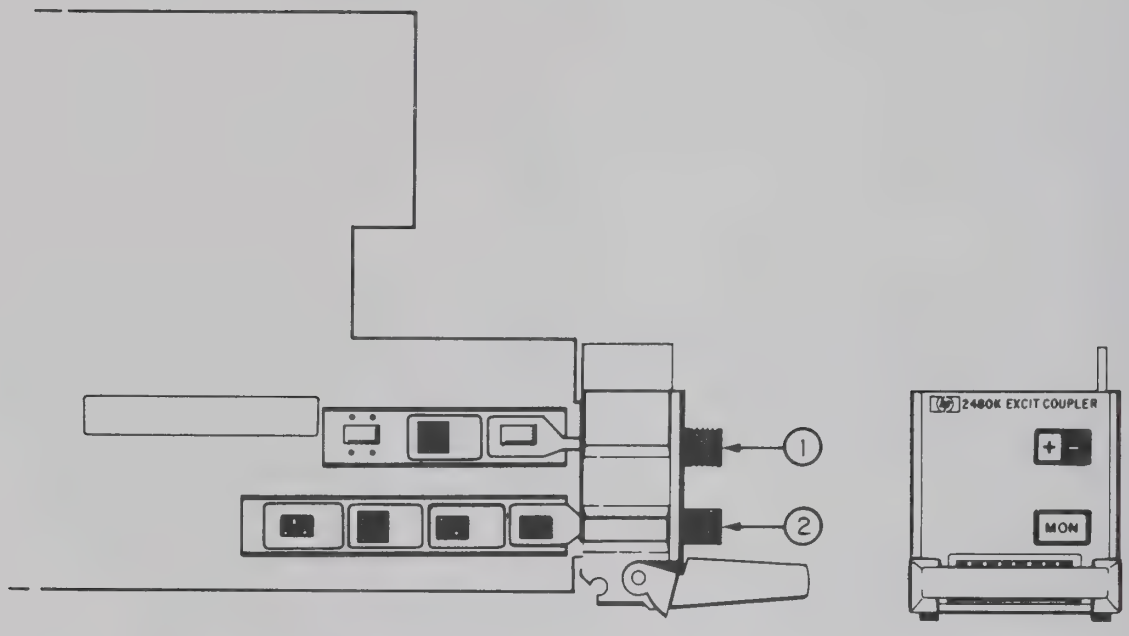


FIGURE 2-9 HP-2480K EXCITATION COUPLER CONTROLS

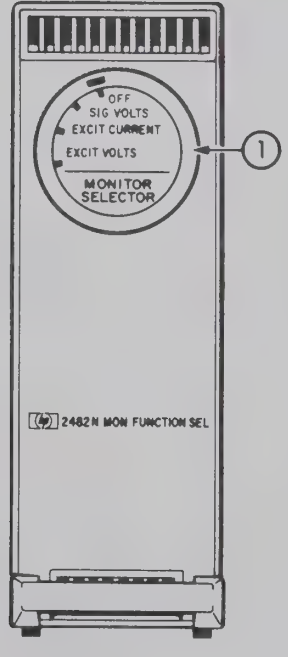


FIGURE 2-10 HP-2482N MONITOR FUNCTION SELECTOR CONTROLS

Table 2-4 HP-2482N Monitor Function Selector Controls

Item	Control	Function
1	MONITOR SELECTOR Switch	Permits the user to select excitation voltage, excitation current, or transducer signal voltage for monitoring by an external voltmeter. A fourth position (OFF) disconnects voltages from the external voltmeter.

2-8 OPERATING PROCEDURES

The detailed operating procedures used with the HP-2480A series Signal Conditioning Equipment will be determined by the specific equipment application and the type of data sensing and wiring configuration used (Paragraph 2-3). However, typical procedures for four commonly used modes of operation are described for the general guidance of the user. These are:

a. Linear mode of operation
b. Constant voltage, remote sense, mode of operation
c. Constant voltage, local sense, mode of operation
d. Constant current mode of operation

CAUTION

Do not connect transducers to the conditioning equipment unless the necessary adjustments are made of the 2480A and 2481A. The 2480A is capable of delivering enough power to damage some types of transducers.

2-9 Linear Mode of Operation

a. Remove the 2481A from the instrument case and set the 2480A controls as follows:

CONSTANT VOLTAGE or CONSTANT CURRENT switch to CONSTANT VOLTAGE position.

GAIN X1 or GAIN X6 switch to the Gain X1 position

POLARITY REVERSAL + or - switch to the desired polarity

EXCIT ADJ control counterclockwise to the minimum excitation voltage position.

b. Load a 2481A Resistor Board in accordance with Figure 2-4 and insert into the connector on the 2481A Control Board.

c. Set the 2481A Resistance Bridge controls as follows:

SENSE switch to the REMOTE position.

EXC MON switch to the LOCAL position.

d. Install the 2481A in the instrument case and install the entire assembly in the appropriate combining case channel.

e. Monitor the excitation voltage in one of the following ways:

With a 2482N set to the EXCIT VOLTS position and connected to a voltage measuring instrument.

With a voltage measuring instrument connected directly to the excitation voltage monitoring terminals on the rear of the combining case.

f. Turn the EXCIT ADJ control clockwise until the excitation voltage is at the desired level. The monitor will read the total voltage on the bridge.

g. Monitor the transducer signal voltage in one of the following ways:

With a 2482N set to the SIG VOLTS position and connected to a voltage measuring instrument. Press the MON control on the 2481A of the appropriate channel to monitor.

With a voltage measuring instrument connected directly to the signal voltage monitoring terminals on the rear of the combining case. Press the MON control on the 2481A of the appropriate channel to monitor.

With the system measuring device connected to the signal output terminals of the appropriate channel.

h. With the transducer stimulus in the "reference state" adjust the BAL control on the 2481A to obtain a zero or null output on the signal monitor.

i. To shunt calibrate energize a calibration relay, either by depressing the 2481A CAL control or by providing a 24 volts (±20%) relay energizing supply via the appropriate external "Cal Power" line.

j. The excitation current delivered to the bridge and the balance potentiometer can be measured in one of the following ways:

With the 2482N set to the EXCIT CURRENT position and connected to a voltage measuring instrument. The voltage measuring instrument will measure one millivolt for each milliamp of current delivered to the bridge and balance circuit. Press the MON control on the appropriate channel to monitor.

Without a 2482N, a resistive shunt, preferably one ohm, must be connected across the current monitor terminals of the combining case and the voltage drop across the resistor measured with a voltage measuring instrument. Press the MON control on the appropriate channel to monitor.

2-10 Constant Voltage, Remote Sense Mode of Operation

a. Remove the 2481A from the instrument case and set the 2480A controls as follows:

CONSTANT VOLTAGE or CONSTANT CURRENT switch to the CONSTANT VOLTAGE position.

GAIN X1 or X6 switch to the "Gain X6" position.

POLARITY REVERSAL + or - switch to the desired polarity.

EXCIT ADJ control counterclockwise to the minimum excitation voltage position.

b. Load a 2481A Resistor Board in accordance with Figure 2-6 and insert the board into the connector on the 2481A Control Board.

c. Set the 2481A Resistance Bridge controls as follows:

SENSE switch to the REMOTE position.

EXC MON switch to the REMOTE position.

d. Perform steps d through j of section 2-9.

2-11 Constant Voltage, Local Sense Mode of Operation

a. Remove the 2481A from the instrument case and set the 2480A controls as follows:

CONSTANT VOLTAGE or CONSTANT CURRENT switch to the CONSTANT VOLTAGE position.

GAIN X1 or X6 switch to the GAIN X6 position.

POLARITY REVERSAL + or - switch to the desired polarity.

EXCIT ADJ control counterclockwise to the minimum excitation voltage position.

b. Load a 2481A Resistor Board in accordance with Figure 2-3, 2.5, or 2.6 and insert the board into the connector on the 2481A Control Board.

c. Set the 2481A Resistance Bridge controls as follows:

SENSE switch to the LOCAL position.

EXC MON switch to the LOCAL position.

d. Perform steps d through j of section 2.9.

2-12 Constant Current Mode of Operation

a. Remove the 2481A from the instrument case and set the 2480A controls as follows:

CONSTANT VOLTAGE or CONSTANT CURRENT switch to the CONSTANT CURRENT position.

GAIN X1 or GAIN X6 switch is inoperative in the constant current mode.

POLARITY REVERSAL + or - switch to the desired polarity.

b. Load a 2481A "Resistor Board" in accordance with Figure 2-3, 2-5, or 2-6, and insert the board into the connector on the 2481A "Relay Board".

NOTE

Since the balance potentiometer circuit is in shunt with the output of the constant current source,the balance circuit will adversely affect the regulation of the constant current source. Most users prefer to alter the balance circuit by omitting either R11 or R13; others prefer to omit the balance circuit completely by omitting both R11 and R13.

c. Set the 2481A Resistance Bridge controls as follows:

The SENSE switch is ineffective in the constant current mode.

EXC MON switch to the LOCAL position for monitoring bridge voltage at the resistor board or to the REMOTE position for monitoring at the bridge location.

d. Install the 2481A in the instrument case and install the entire assembly in the appropriate combining case channel.

e. Monitor the excitation current as described in section 2-9(j)

f. Turn the EXCIT ADJ control clockwise and raise the excitation current to be the desired level. The monitor will read the total current delivered to the combined bridge and balance pot circuit.

g. Perform steps g, h, and i of 2-9.

SECTION 3

THEORY OF OPERATION

3-1 HP 2480A DC EXCITATION SOURCE

The HP-2480A DC Excitation Source is an adjustable 30 volts, 200 milliamperes power supply which operates as an integral part of the HP-2480 series Signal Conditioning Equipment to provide bridge excitation. The excitation source circuits may be divided on a functional basis into the following main divisions:

a. Unregulated Power Supplies
b. 18 Volts Regulator
c. DC Reference Source
d. Differential DC Amplifier
e. Mode Switching circuits
f. Monitor Circuits
g. Transient Suppressor

The relative arrangement of these is shown in Figure 4-1.

3-2 Unregulated Power Supplies

The unregulated power supply circuits provide the basic power requirements of the excitation source. Transformer T1 and three bridge rectifier circuits, comprising diodes CR1 thru CR12, provide +45v, ±27v and +22v supplies. The +45 volts supply which is filtered by C1 is used in the Differential DC Amplifier, the ±27 volts supply, filtered by C3 and C4, is used as a source for the 18 Volt Regulator circuits and the +22 volts supply, filtered by C9, is used as a source for the DC Reference Circuits. The transformer T1 has three interwinding shields to reduce injected noise current and the guarded capacity to ground.

3-3 Volts Regulator

The 18 Volts Regulator circuits provide ±18 volts regulated supplies from the ±27 volts unregulated input. The 18 volts regulated supplies are used for the operation of critical circuits in the Differential DC Amplifier.

Regulation is achieved in a conventional manner. Transistors Q1 and Q2 act as series and control components respectively for the +18 volt supply.

3-4 DC Reference Source

The DC Reference Source circuits provide a highly stable, adjustable, dc voltage for use as the reference input to the differential dc amplifier. The reference circuits consist of Q15, Q16, Q17, Q18, CR17, CR24 and the associated components. Transistor Q15, Q16 and Q17 are differential amplifiers which drive the emitter follower Q18, which is connected to the zener reference diode CR17. The amplifier which has a high open loop gain has feedback applied via R40 and R41 to provide a closed loop gain of approximately 2.5. Connected in this way the amplifier drives the zener diode, CR17, with a constant current which is a requirement for a stable output voltage. The resistor R51 which is connected across CR17 is a multi-turn potentiometer. This permits adjustment of the reference voltage applied to the differential dc amplifier.

The M1 version of the HP-2480A DC Excitation Source has an additional potentiometer connected across the zener reference. This potentiometer, R55, together with the associated resistors R9 and R21 permit vernier adjustment of the reference voltage. In the M2 version of the HP-2480A, the functions of R51 and R55 are reversed. Potentiometer R51 is the vernier adjustment control and R55 is the coarse adjustment.

It should be noted that the DC Reference Source is a floating source; that is, the supply is isolated. The common side of the source is not connected to the common side of the other supplies in the HP-2480A. This arrangement is necessary in providing temperature stable excitation in strain gage systems employing long interconnecting cables.

3-5 Differential DC Amplifier

The Differential DC Amplifier raises the level of the dc reference source to the value required for bridge excitation; it also compensates for any voltage or current changes in the bridge circuit, thus maintaining a constant voltage or constant current condition.

Two inputs are applied to the differential dc amplifier. One is the dc reference source and the other is a "Sense" voltage which is a function of voltage or current changes that occur in the bridge circuit. The two inputs are applied to the base circuits of transistors Q5A and Q5B, which form a differential amplifier. Transistor Q6 is a constant current source for the differential amplifier and stabilizes the quiescent dc operating point. Diodes CR18 and CR19 are included to clamp and protect the base - emitter junctions of Q5A and Q5B in the event of excessive transients occurring. The output of Q5A and Q5B is connected to a second differential amplifier formed by Q7A and Q7B. The output of this is coupled via a selective-frequency network to a single ended negative feedback pair, Q9 and Q10. The selective-frequency network is formed by capacitor C14 and the input impedance of Q9. It results in a roll-off in response above

10 cps at a rate of 6 db per octave. Transistor Q12 is a constant impedance and ensures a stable quiescent operating point. The output of Q10 drives two cascaded emitter followers, Q11 and Q14. The output of Q14 is the bridge excitation source.

The Differential DC Amplifier has an open loop gain of approximately 2×10^5 However the inclusion of feedback resistors R4 and R8 reduces this to 5.5. The negative feedback provides a very low output impedance for constant voltage operation and a very high impedance for constant current operation. In the constant voltage mode of operation the feedback is taken from the emitter of Q14. In the constant current mode a voltage proportional to the output current flowing through sensing resistor R39, is fed back.

The transistor Q13 provides short circuit protection for the excitation source. Normally the transistor is cut off but if the output terminals (J1-2 and J1-12) are shorted, the resulting voltage drop across R37 causes the transistor to conduct. This restricts the base current drive to the emitter follower Q11 and limits the short circuit current. The actual value of the short-circuit current is adjustable. Resistor R36, a preset potentiometer located on the HP-2480A printed circuit board, may be adjusted to restrict the short-circuit current to any value between 80 and 300 milliamperes.

3-6 Mode Switching Circuits

The Mode Switching Circuits set the appropriate circuit conditions for the three modes of operation: constant voltage, constant current and linear. In addition they permit the user to select either positive or negative bridge excitation. The actual switches used for these purposes are the CONSTANT VOLTAGE/CONSTANT CURRENT switch (S1) the GAIN 1/5.5 switch (S5) and the +/- switch (S2). These are slide switches which are mounted internally on the HP-2480A printed circuit board. The mode switches (S1 and S5) essentially select the appropriate amplifier gain, by controlling the degree of negative feedback, and make the necessary sensing connections.

In the constant voltage mode the amplifier closed-loop gain is set to 5.5 and the sensing connections are made to monitor the excitation source. Monitoring may be done locally at the HP-2481A Resistance Bridge or remotely at the transducer, as desired by the user. Any excitation voltage variations are applied to the differential dc amplifier and cancelled. The amplifier closed-loop gain is set to 5.5 by the feedback components R7 and R8 which are switched in the feedback circuit, in the desired configuration, by the contacts of switch S1 (Figure 4-1). The linear mode control switch (S5) is in series with switch contacts S1A and must be in the GAIN 5.5 position for correct operation of the constant voltage mode. The 5.5 gain factor results in the dc reference input to the differential amplifier being amplified by 5.5 at the excitation output terminals.

The linear mode circuit arrangement is similar to that used in the constant voltage mode, but the amplifier closed-loop gain is set to 1. This is achieved by modifying the amplifier feedback arrangement by placing the linear mode control switch (S5) in the GAIN 1 position.

In the constant current mode the amplifier closed loop gain is set to 1 and the sense connections are made to a current sensing resistor (R39) which is wired in series with the excitation supply. Voltage variations across the sensing resistor, occurring as a result of excitation current changes, are applied to the differential dc amplifier and cancelled. The amplifier closed-loop gain is set to 1 by the feedback components R7 and R8 which are switched in the feedback circuit, in the desired configuration, by the contacts of S1.

Excitation source polarity reversal is effected by the +/- slide switch (S2). This may be operated from the HP-2480A front panel. Sections S2A and S2B reverse the excitation leads while S2E and S2F simultaneously reverse the sense leads. While the changeover is being effected, S2C and S2D short the excitation leads through resistor R56 to prevent switching transients being applied to the energized transducer.

3-7. Monitor Circuits

The monitor circuits in the HP-2480A DC Excitation Source operate in conjunction with the HP-2482N Monitor Function Selector, and an external measuring device, to monitor the bridge excitation voltage and current. Contacts of the front panel MON switch (S3) connect the excitation voltage and current components to monitor buss lines, on the combining case mother board, which connect to the Monitor Function Selector. Contacts S3E/F switch the excitation voltage and contacts S3C/D switch the excitation current. Additional contacts S3G and S3H switch the monitor line guard and the energizing source for a control relay respectively. These are used if equipment in more than one combining case is to be monitored by a single Monitor Function Selector. Switching the monitor guard permits different combining cases to be operated at different guard potentials without causing a guard short. The control relay is arranged to switch the monitor lines of a combining case to the single Monitor Function Selector only when the MON switch is operated thus permitting more than one combining case to be used with one Monitor Function Selector. A more detailed description of the overall monitoring system is given in paragraph 3-11, which relates to the Monitor Function Selector.

3-8 Transient Suppressor

The transient suppressor circuits, comprising Q12 and Q19, prevent transients appearing at the excitation source output when the excitation source is switched on or off. Such transients would occur due to the different charging and discharging rates of capacitors C1, C3, C4 and C9, etc.

During normal operation, when both the ±18v and 45v supplies are available, the Q19 base/emitter potential is such that the transistor conducts and provides base current for the constant current transistor Q12. This results in Q12 conducting and supplying current for the operation of Q10. However, immediately after turn-on, before the 18v supply is available, Q19 is cut off. This in turn holds-off Q12 and prevents current being supplied to Q10. During turn off Q19 and Q12 operate in a similar way via the subsidiary negative feedback loop comprising C19, R58 and CR23.

3-9 HP-2481A RESISTANCE BRIDGE

The Resistance Bridge (Figure 4-2) is a multi-purpose circuit which may assume many configurations. Figure 4-2 includes the Control Board A1 and its accessory Resistor Board A2.

Figure 4-2 consists of a Resistance Bridge A1 that has received Modification M5 and M6. Rotary CALIBRATION STEP switch S7 (added by M6) locally selects one of six calibration step relays K1 through K6 that are present when M5 is present. Diodes isolate S7 selections from the external select lines. The functions of controls are presented in Table 2-2. If modifications M1 through M5 or M6 are not present, delete from Figure 4-2 the components added by those modifications not present.

Figure 4-2 does not include any of the possible point-to-point jumper or resistor connections of the resistor board that establish a particular configuration. A few of the possible configurations are shown in Figures 2-3 through 2-6 and described in paragraphs 2-3 through 2-6.

Figure 4-2 also omits the Coupler Board A3 (02481-8001). This board simply connects J1 of the Resistance Bridge A1 pin-for-pin to J1 of the DC Excitation Source A1.

Circuit boards A1 and A2 were designed to provide maximum flexibility to the user. Tuning fork type solder terminals permit the installation of resistors or jumpers as required.

The functions of terminals provided for control board A1 are as follows:

EXTERNAL EXCITATION: These 4 terminals J14 and J15 allow the output of the 2840A to be coupled to the external excitation bus of the combining case mother board. If the divider switch on the mother board is on, a single HP-2480A may power nine other channels as well as its own channel.

If the divider switch is off, a single HP-2480A may power four other channels in one-half of the combining case while a second HP-2480A may power four other channels in the second half. In either case, a module containing its own HP-2480A may be installed in any channel location providing these jumpers are omitted. Two jumpers, located on the combining case accessory board disable the entire external excitation bus.

R14, R15. Appropriate resistors may be installed to provide a voltage divider across the excitation leads. The center of the divider is connected to ground providing a ground return for differential amplifier applications using floating inputs. R14 and R15 use 3 terminals sharing 2 of the external excitation terminals.

The functions of terminals provided for resistor board A2 are as follows:

R1A thru R6B. These are positions for the shunt calibration resistors. The numbers 1 thru 6 refer to the calibration steps. For calibration step 1, resistors R1A and R1B are connected to the two pole form A calibration relay K1. The letters A and B refer to the arm of the bridge to which the shunt would be applied. In normal operation the A resistor shunts the -signal, -excitation side of the bridge; the B resistor shunts the +signal, +excitation side of the bridge.

R7 thru R10. These are positions for bridge completion resistors where the transducer is incomplete. In normal practice resistors R7, R9 and R10 are used to complete a bridge for a single arm transducer and resistors R9 and R10 are used to complete a bridge for a transducer with two adjacent arms. For transducers with complete internal bridges no completion resistors are required on the board.

R11 thru R13. These three resistors in conjunction with the balance potentiometer form the bridge balance circuit. In constant voltage operation R11 and R13 are jumpers and R12 is selected to provide the proper balance span for the type of transducer in use. In constant current operation R12 is usually jumpered to provide a maximum series resistance in R11 and R13 to avoid shunting the output impedance of the constant current source. In some cases it may be desirable to omit R11 and R13 completely to preserve the maximum regulation of the constant current mode.

J1 thru J3. J1 thru J3 are used to vary the calibration circuit to suit the bridge type. In single active arm bridge types where three bridge completion resistors are provided internally J1 connects the "B" calibrate resistors to the +signal bridge corner. J5 is also required to provide connection between the calibrate relay and the +excitation bridge corner. With either two or four

active arm transducers both J2 and J3 are required to complete the normal calibration circuits. If J2 and J3 are diagonally criss-crossed the effect is to reverse the polarity of the calibration steps by applying the shunts to the + excitation, -signal and - excitation, + signal sides of the bridge.

J4 thru J7. When a self contained four arm bridge transducer is used and extra conductors are connected to the bridge for the purpose of shunt calibration, errors resulting from sharing conductors for excitation and calibration are eliminated. Such systems are referred to as "six-wire" or "eight-wire" systems depending on whether conductors are provided for a single shunt or a pair of shunts. In conventional "four-wire" where the excitation and signal conductors must also carry calibration currents, errors in the calibration result from the voltage drop in the excitation conductors and signal offsets may result from the calibration currents in the signal conductors.

In order to provide for the occasional user of four-wire calibration and also to provide for internal calibration where bridge completion resistors exist on the board, jumper positions J4 thru J7 are available. One or more of these jumpers will be required when calibrating bridges with completion resistors on the board.

J8 and J9. J8 and J9 are used to select the signal conductor for the bridge. In normal operation J9 connects the - signal output to the - signal corner of the external bridge.

Where only one arm of the bridge is external the conductor normally used for - signal becomes an excitation conductor and a separate signal conductor must be used to avoid errors due to the voltage drop in the excitation conductor. A conductor otherwise used for a + signal calibrate conductor in the "eight-wire" calibration mode is borrowed for use as the - signal conductor. Connection to this conductor is made through J8.

J10 and J11. If separate conductors are not available for remote excitation monitoring, the + excitation and - excitation calibration conductors of an "eight-wire" calibration system can double as remote excitation monitor conductors. No interaction will occur providing excitation monitoring and bridge calibration are not done simultaneously. This double use is accomplished by installing J10 and J11 and setting the Local/Remote Monitor switch to remote.

J12 and J13. In the linear mode the remote sense leads must be connected across the R-7 completion resistor. This is accomplished by installing jumpers J12 and J13 and setting the Local/Remote Sense switch to the Remote position.

SIG PAD. The four terminals of the "SIG PAD" are available for the installation of attenuating or filtering pads in the signal circuit. If no pad is desired jumpers must be installed in the positions SIG and PAD as shown by the solid lines on the circuit board and dashed lines on Figure 4-2.

Variations. Numerous other variations are possible by selective wiring of the terminals. For example, replacement of J5 by a jumper from the top end of J5 and the right end of R10 will reverse the calibration polarity for the single active arm mode.

3-10. HP-2480K EXCITATION COUPLER.

The Excitation Coupler (Figure 4-3) replaces the basic HP-2480A DC Excitation Source as described in paragraph 1-4.

3-11. HP-2482N MONITOR FUNCTION SELECTOR.

The Monitor Function Selector (Figure 4-4) may be installed in place of a 2480A/2481A instrument in the combining case where it will engage receptacle J1 through J10 according to the channel location selected. With this configuration, it is possible to monitor bridge excitation voltage or current and the bridge output signal of any channel on a voltmeter connected to the signal connector J21 through J30 (associated with J1 through J10, respectively, that received the 2482N). A rotary switch selects one of the three signal types to be measured. The 2482N contains a standard 1-ohm resistor for the current measurement function.

The functions of this instrument may be extended to monitoring 2480A/2481A instruments in adjacent combining cases. Selective relays in the combining case prevent simultaneously measurement or monitoring in two combining cases when this configuration is used.

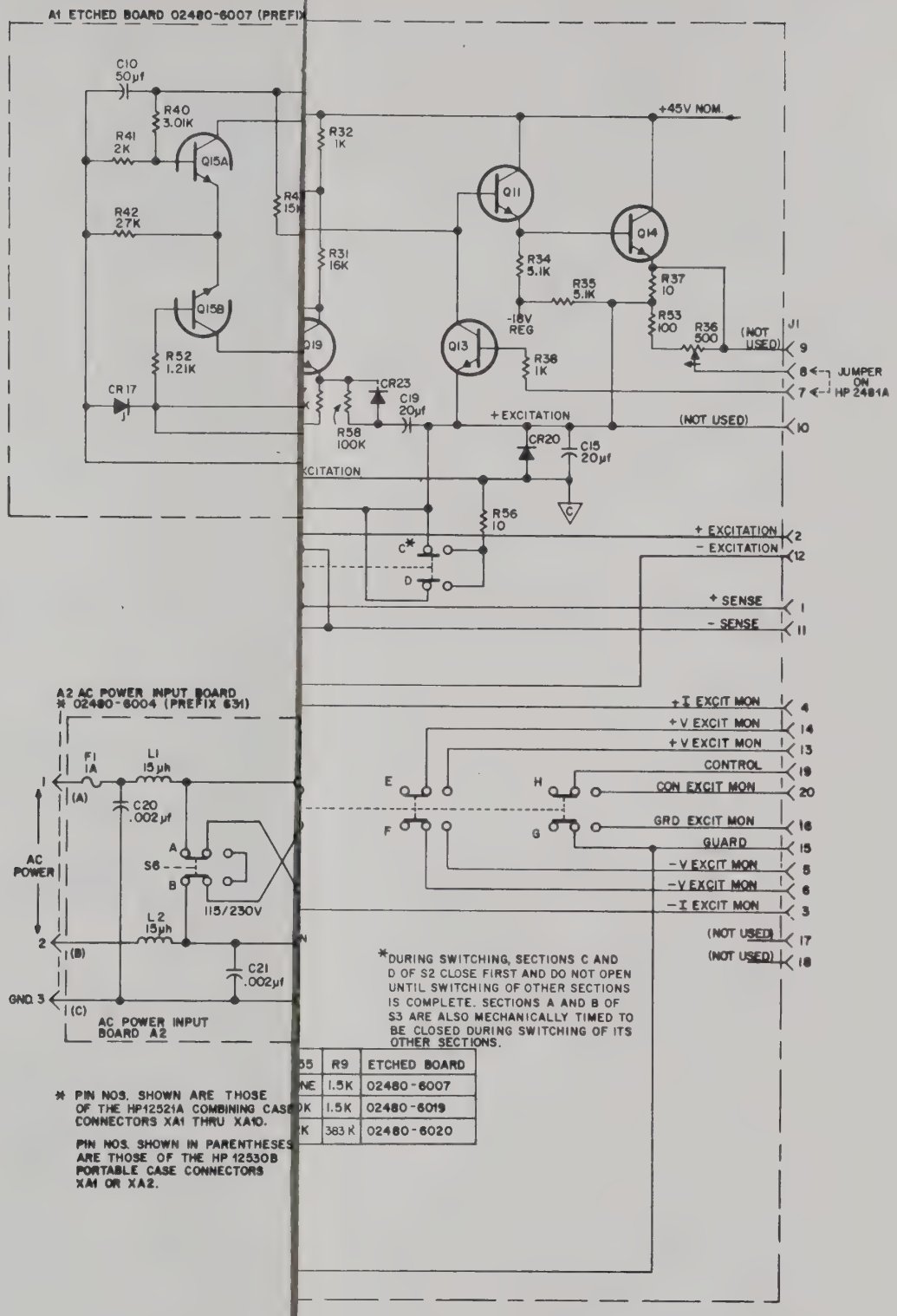
SECTION 4

MAINTENANCE

4-1. INTRODUCTION.

Maintenance instructions for the HP-2480 series Signal Conditioning Equipment are not available at the time of publication. As an aid to troubleshooting, the following schematics are furnished:

Figure 4-1 HP-2480A DC Excitation Source
Figure 4-2 HP-2481A Resistance Bridge
Figure 4-3 HP-2480K Excitation Coupler
Figure 4-4 HP-2482N Monitor Function Selector
Figure 4-5 HP-12521A Combining Case Control Board
Figure 4-6 HP-2481A-M7 Resistance Bridge



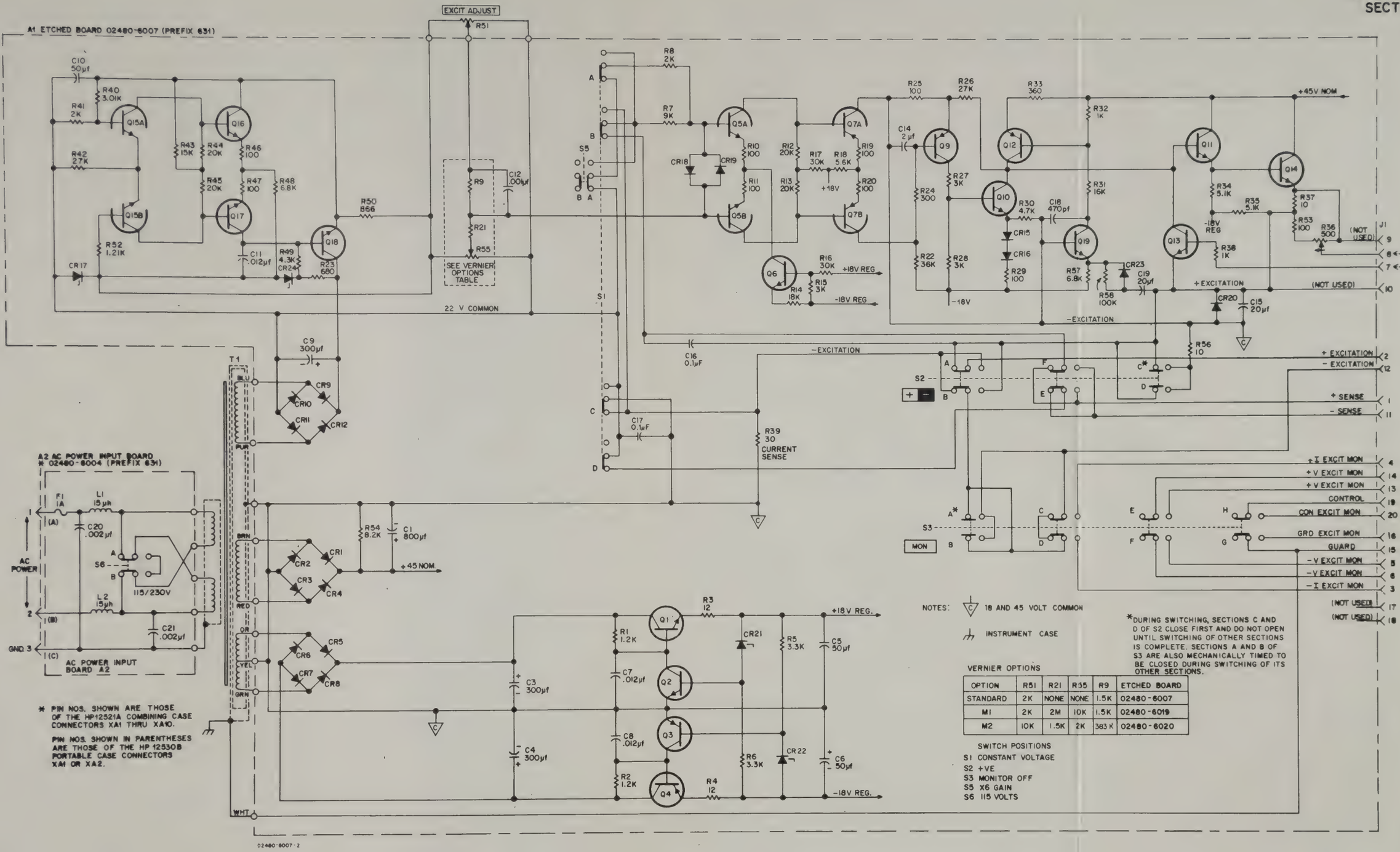
*DURING SWITCHING, SECTIONS C AND D OF S2 CLOSE FIRST AND DO NOT OPEN UNTIL SWITCHING OF OTHER SECTIONS IS COMPLETE. SECTIONS A AND B OF S3 ARE ALSO MECHANICALLY TIMED TO BE CLOSED DURING SWITCHING OF ITS OTHER SECTIONS.

	R9	ETCHED BOARD
NE	1.5K	02480-6007
0K	1.5K	02480-6019
K	383 K	02480-6020

* PIN NOS. SHOWN ARE THOSE OF THE HP12521A COMBINING CASE CONNECTORS XA1 THRU XA10.

PIN NOS. SHOWN IN PARENTHESES ARE THOSE OF THE HP 12530B PORTABLE CASE CONNECTORS XA1 OR XA2.

FIGURE 4-1 HP-2480A DC EXCITATION SOURCE



OPTION	R51	R21	R35	R9	ETCHED BOARD
STANDARD	2K	NONE	NONE	1.5K	02480-6007
M1	2K	2M	10K	1.5K	02480-6019
M2	10K	1.5K	2K	383K	02480-6020

FIGURE 4-1 HP-2480A DC EXCITATION SOURCE
4-3/4-4

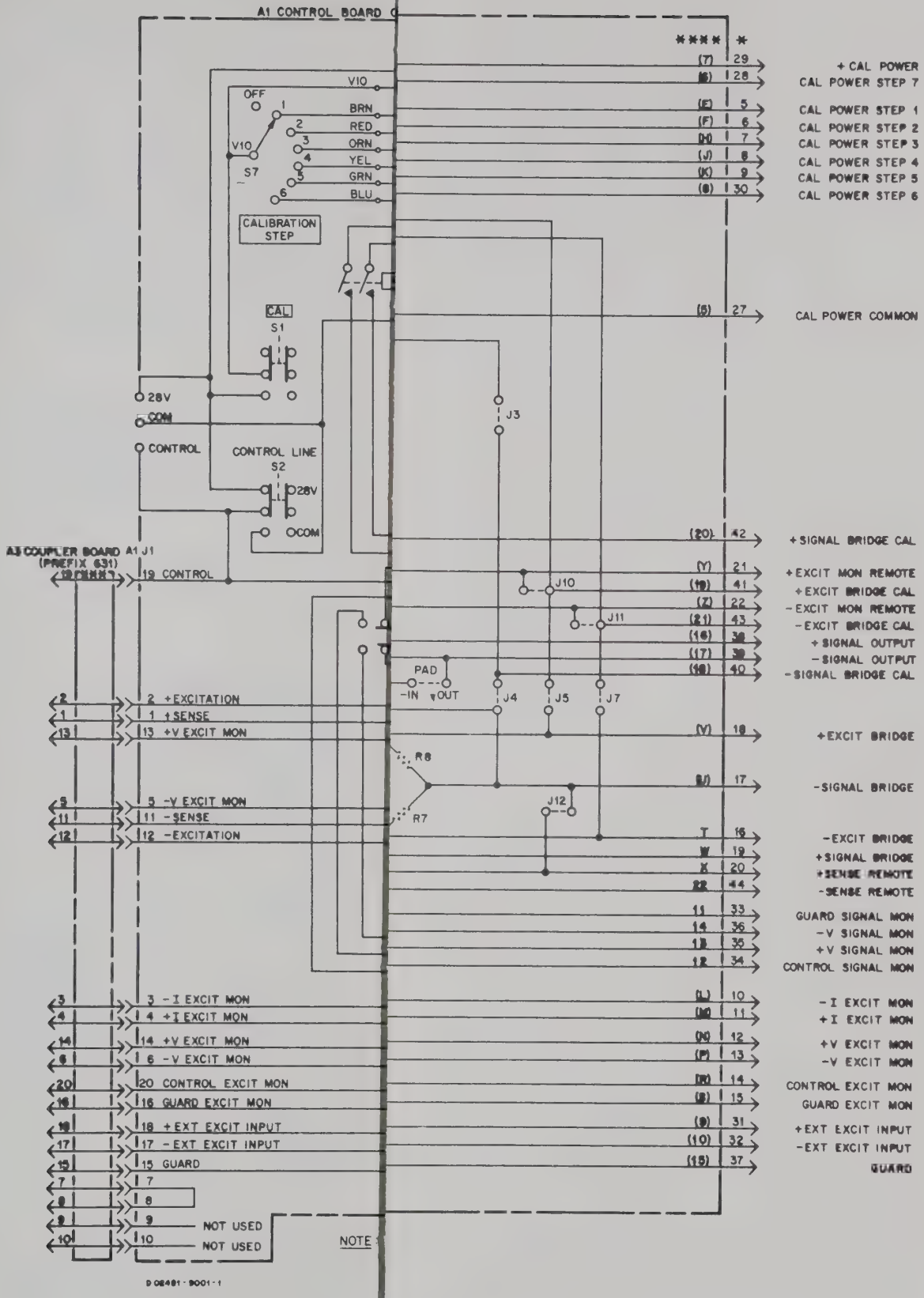
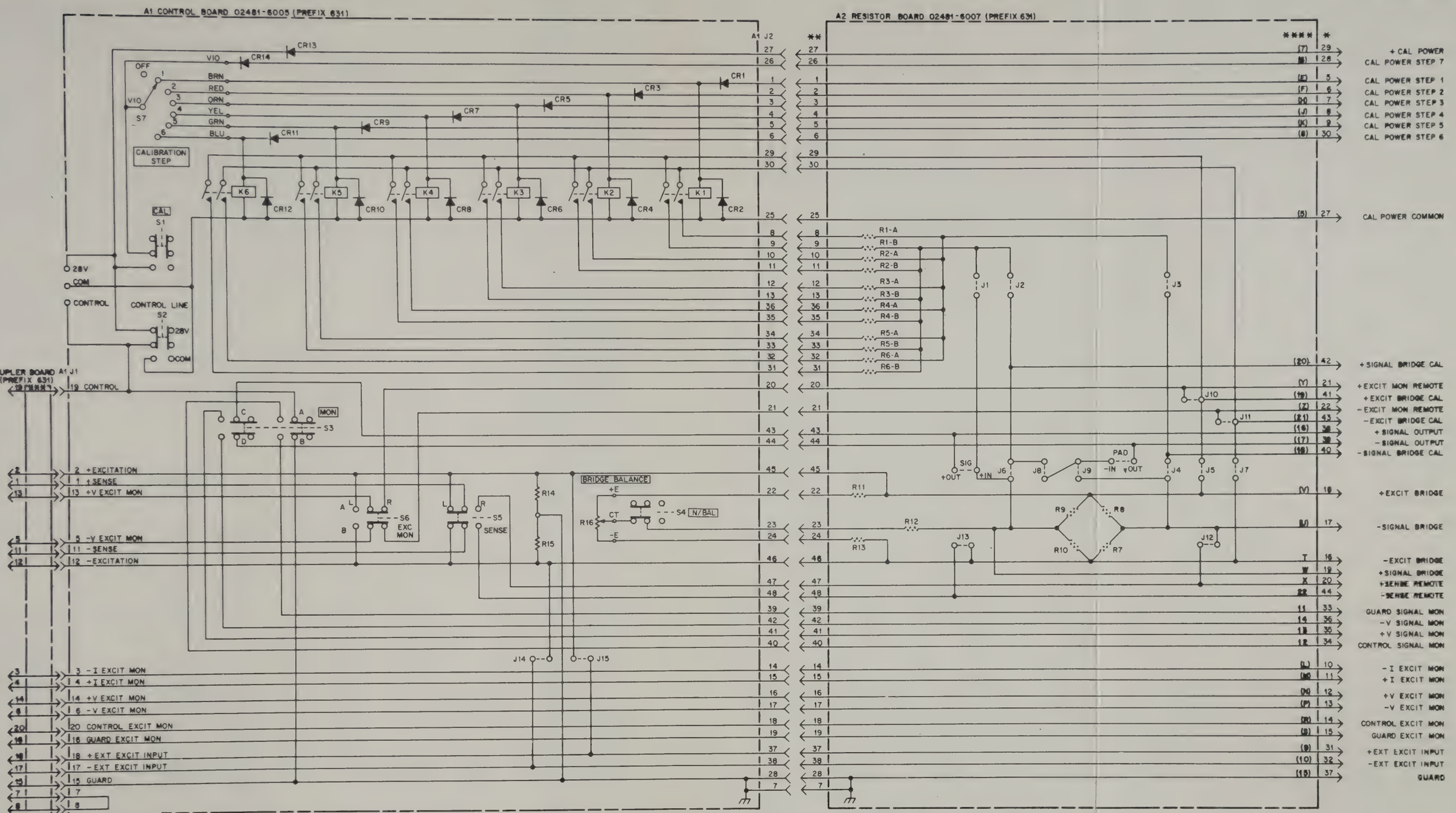


FIGURE 4-2 HP-2481A
RESISTANCE BRIDGE



NOTE: THIS SCHEMATIC REPRESENTS THE *hp* 2481A M5/M6, THE MOST COMPREHENSIVE VERSION OF THE INSTRUMENT. THE TABLE TO THE RIGHT PROVIDES DETAILS ON THE OTHER VERSIONS

* PIN NOS. SHOWN ARE THOSE OF HP 12521A COMBINING CASE CONNECTORS XA1 THRU XA10.

** PIN NOS. SHOWN ARE THOSE OF THE CONTROL BOARD CONNECTOR A1J2.

*** PIN NOS. SHOWN ARE THOSE OF THE EXCITATION SOURCE CONNECTOR A1J1.

INSTRUMENT	SCHEMATIC CHANGES
STANDARD	DELETE S7 AND K2 THRU K6
M1	DELETE S7 AND K3 THRU K6
M2	DELETE S7 AND K4 THRU K6
M3	DELETE S7 K5 AND K6
M4	DELETE S7 AND K6
M5	DELETE S7
M6	DELETE K2 THRU K6

**** PIN NOS. SHOWN IN PARENTHESES ARE THOSE OF THE HP 12530B PORTABLE CASE CONNECTORS XA1 OR XA2.

FIGURE 4-2 HP-2481A
RESISTANCE BRIDGE

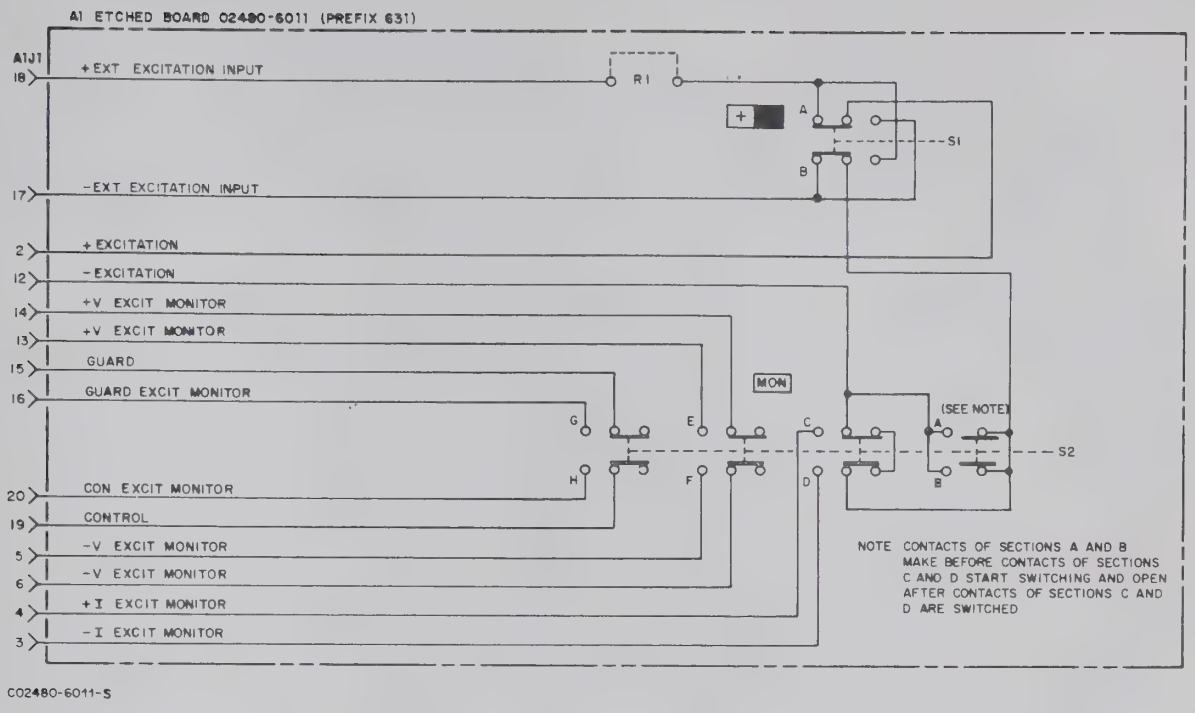


FIGURE 4-3 HP-2480K EXCITATION COUPLER

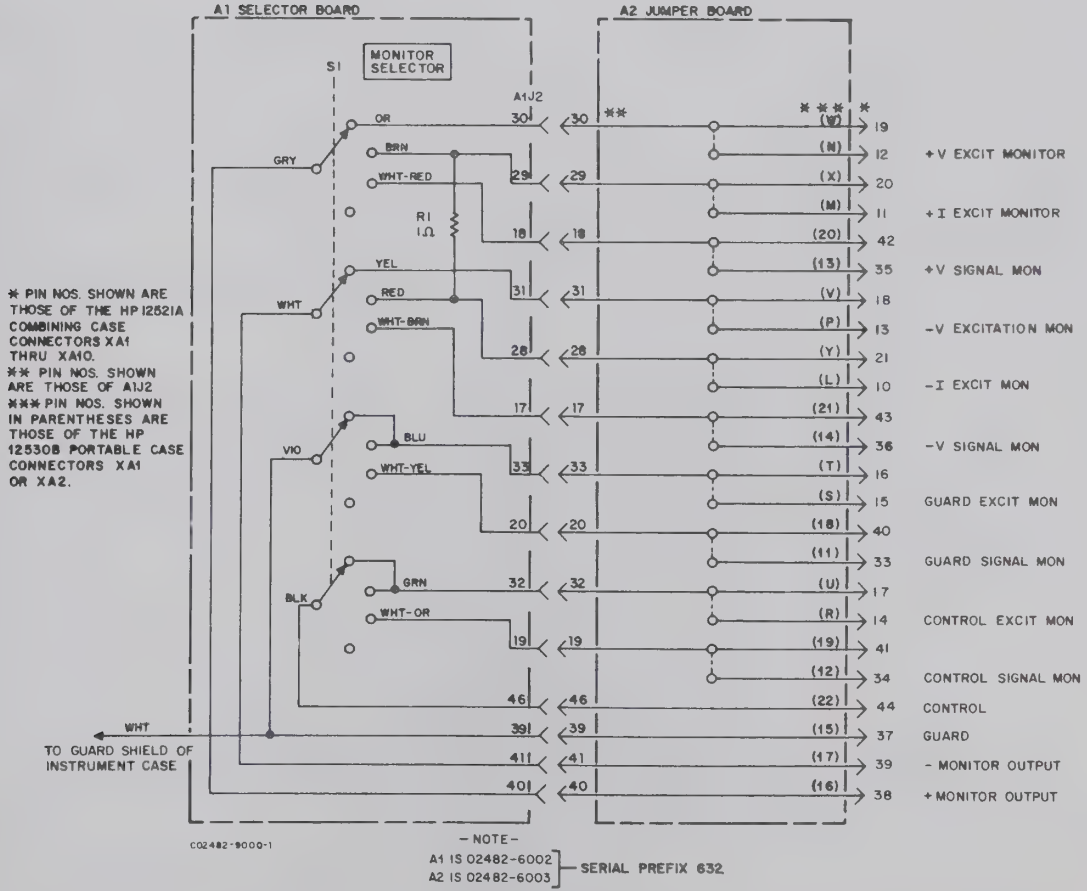


FIGURE 4-4 HP-2482N MONITOR FUNCTION SELECTOR

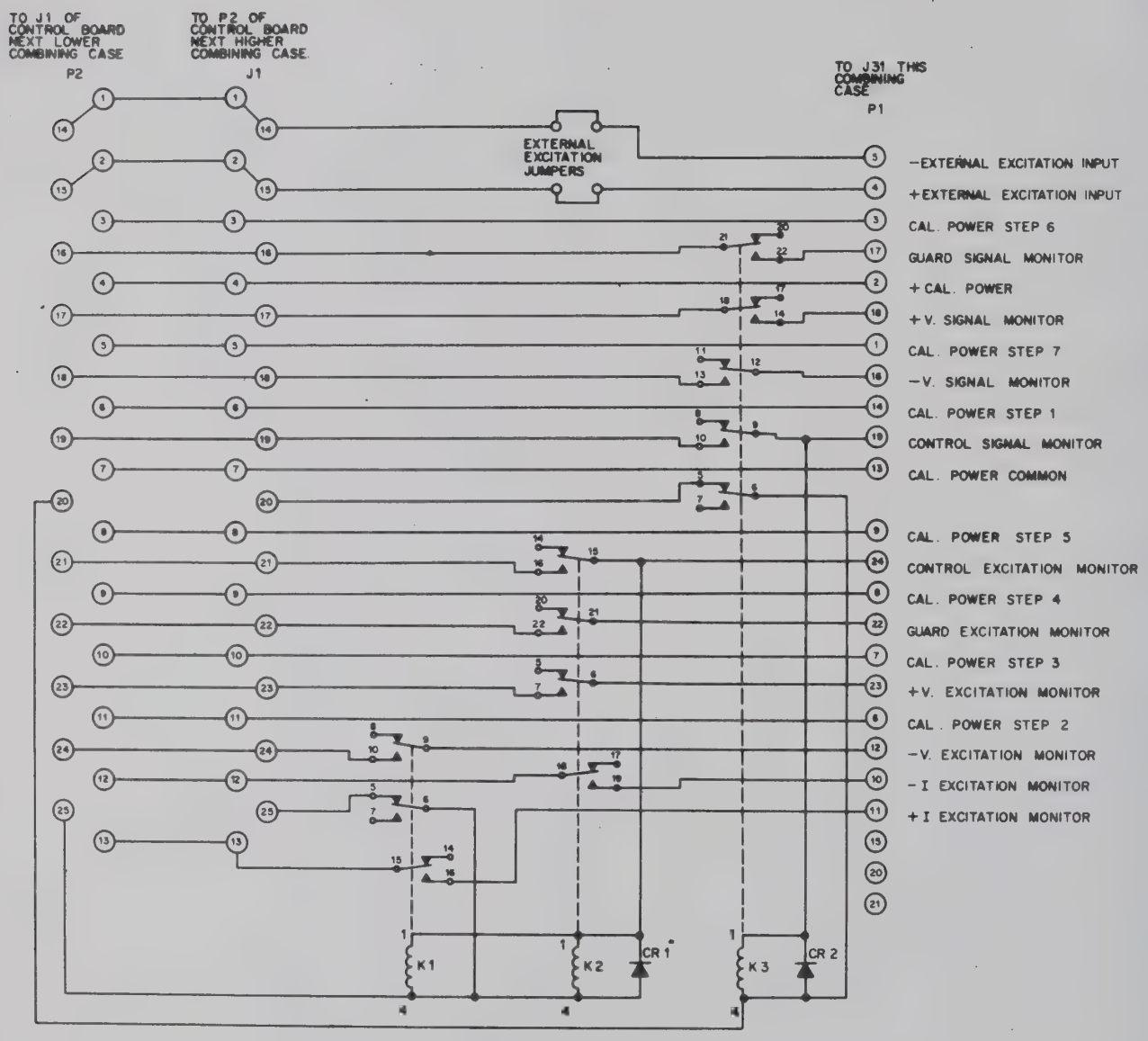
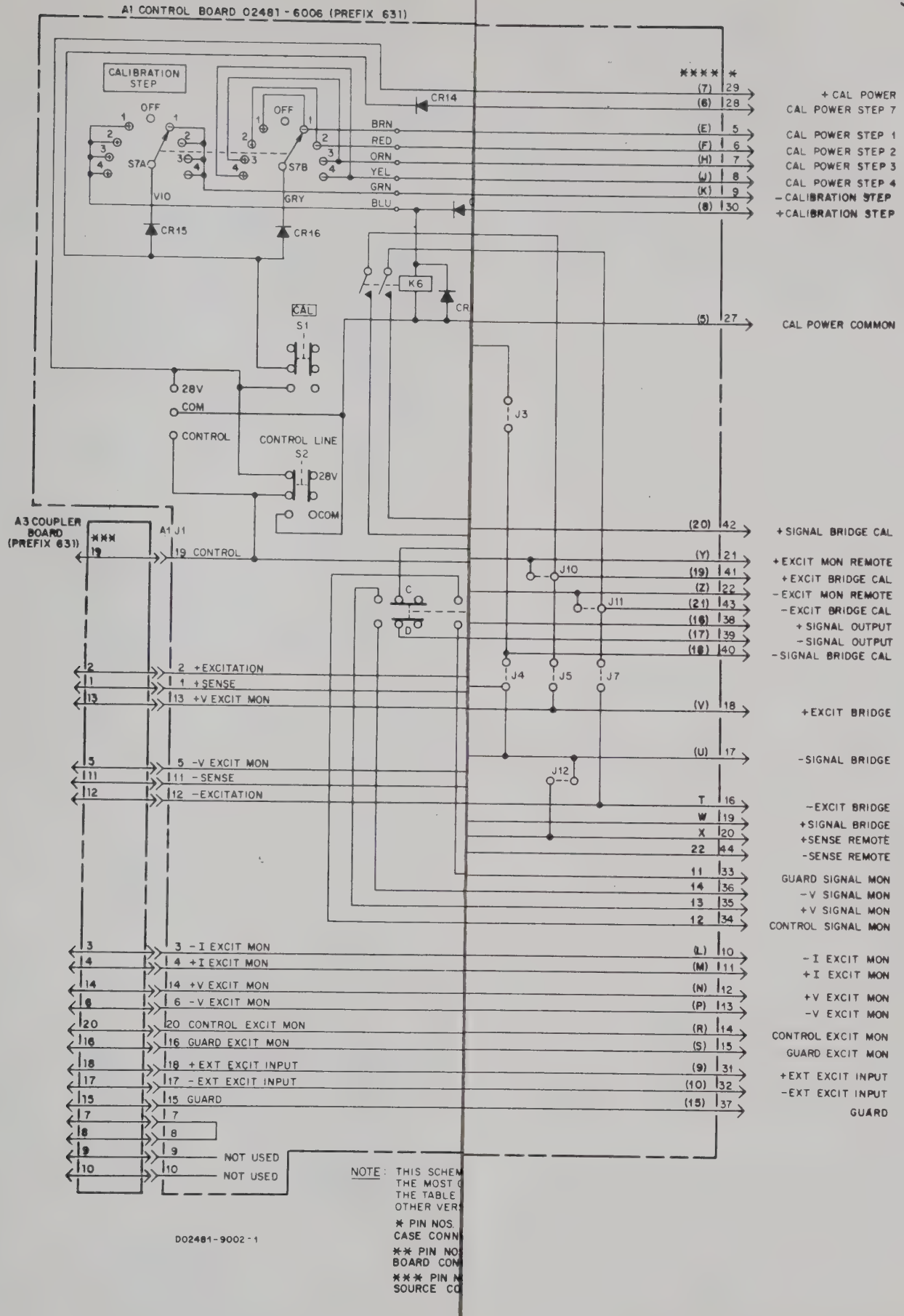


FIGURE 4-5
HP-12521A COMBINING CASE CONTROL BOARD



NOTE: THIS SCHEM
THE MOST C
THE TABLE
OTHER VER

* PIN NOS.
CASE CONN

** PIN NO
BOARD CON

*** PIN N
SOURCE CO

FIGURE 4-6 HP-2481A-M7
RESISTANCE BRIDGE

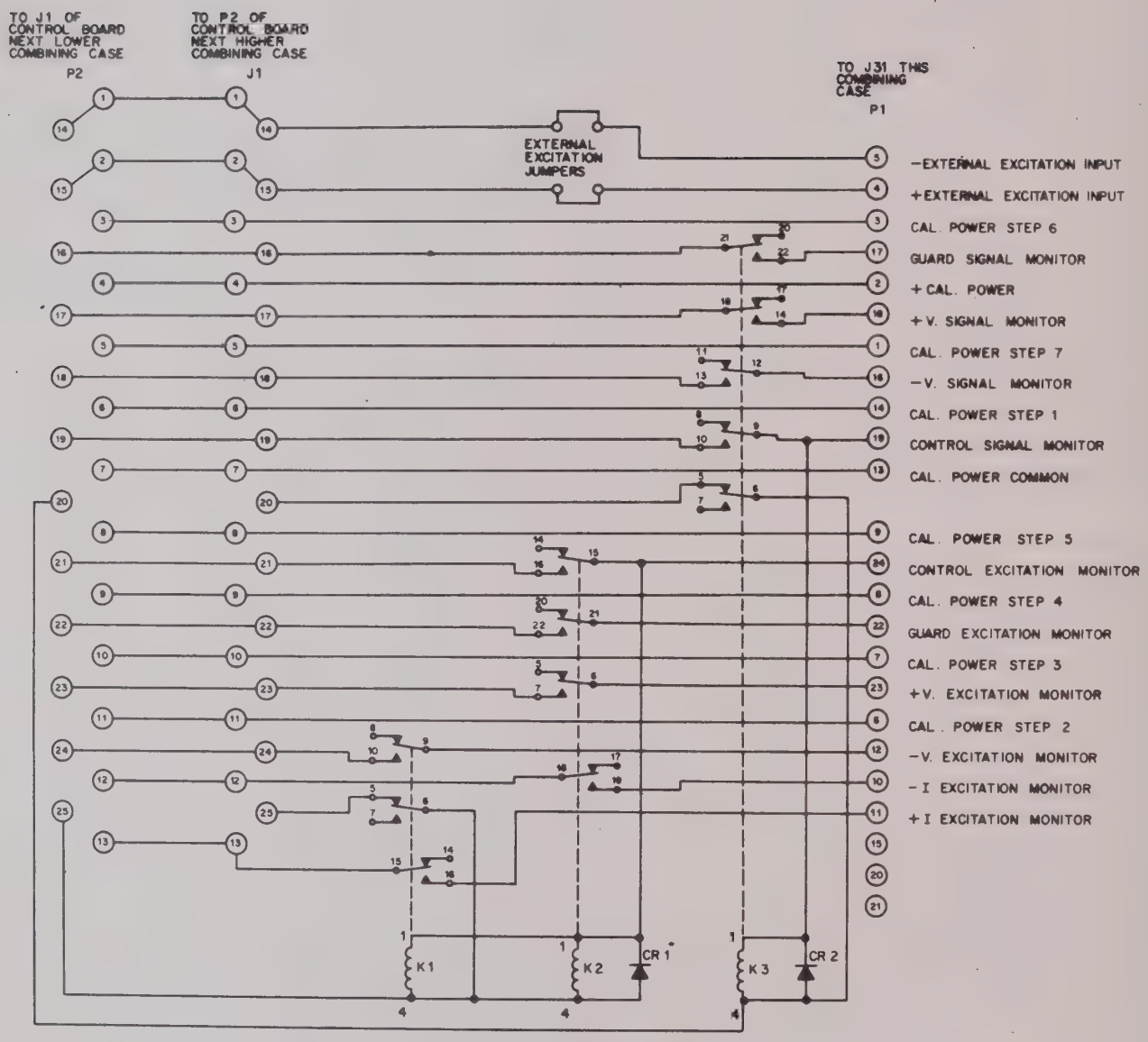
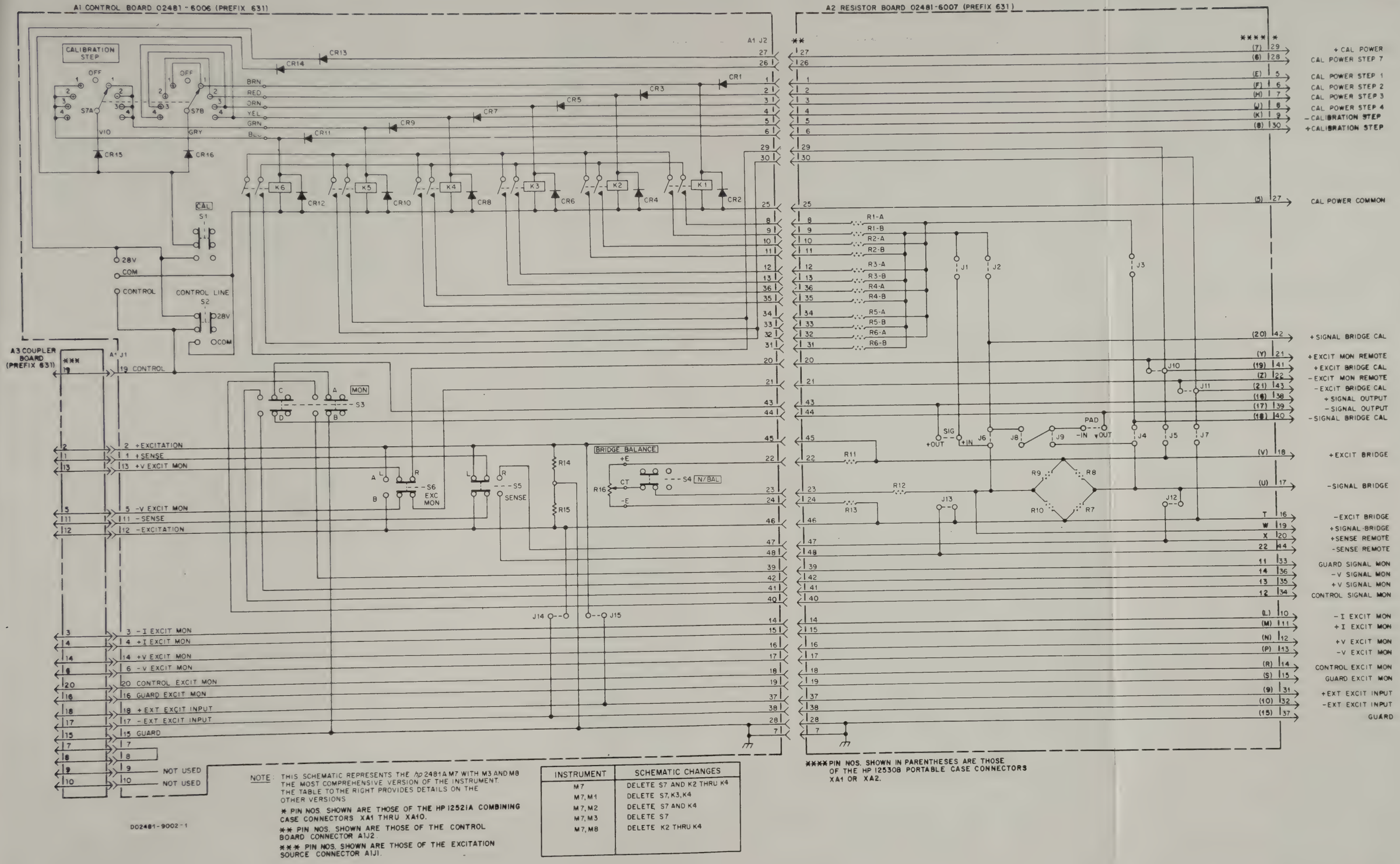


FIGURE 4-5
HP-12521A COMBINING CASE CONTROL BOARD



NOTE: THIS SCHEMATIC REPRESENTS THE hp 2481A M7 WITH M3 AND M8 THE MOST COMPREHENSIVE VERSION OF THE INSTRUMENT. THE TABLE TO THE RIGHT PROVIDES DETAILS ON THE OTHER VERSIONS

* PIN NOS. SHOWN ARE THOSE OF THE HP 12521A COMBINING CASE CONNECTORS XA1 THRU XA10.

** PIN NOS. SHOWN ARE THOSE OF THE CONTROL BOARD CONNECTOR A1J2

*** PIN NOS. SHOWN ARE THOSE OF THE EXCITATION SOURCE CONNECTOR A1J1.

INSTRUMENT	SCHEMATIC CHANGES
M7	DELETE S7 AND K2 THRU K4
M7, M1	DELETE S7, K3, K4
M7, M2	DELETE S7 AND K4
M7, M3	DELETE S7
M7, M8	DELETE K2 THRU K4

**** PIN NOS. SHOWN IN PARENTHESES ARE THOSE OF THE HP 12530B PORTABLE CASE CONNECTORS XA1 OR XA2.

FIGURE 4-6 HP-2481A-M7
RESISTANCE BRIDGE

SECTION 5
TABLE OF REPLACEABLE PARTS

5-1 INTRODUCTION

This section contains identification and ordering information for replacement parts. Any changes to the Table of Replaceable Parts will be listed on a Change Sheet at the rear of this handbook. Note that Dymec uses ℎ stock numbers. A part described as ℎ only is a special part that can be obtained only from the Hewlett-Packard Co. If another manufacturer's stock (part) number is listed, the part may be obtained directly from that manufacturer. A list of manufacturers' code numbers will be found in the Appendix at the end of the Table. In general, parts available from manufacturers other than those listed may be used if the part has equivalent electrical and physical characteristics and quality.

As noted on schematic diagrams, the optimum electrical value of certain components may be selected at the factory to compensate for variations in other components, wiring capacitance, etc. In some instruments, a selected part may be omitted (e.g., a selected resistor might be a wire or an open circuit). The nominal (or average) value of the part is indicated on the schematic diagram. When replacing, use the original value of the part installed in your instrument.

The Table lists parts in alpha-numerical order of their reference designation and provides the following information on each part:

1. Description (see list of abbreviations used, paragraph 5.3).
2. ℎ stock number or Dymec drawing number.
3. Typical manufacturer of the part in a five-digit code (see list of manufacturers in Appendix).
4. Manufacturer's part, stock, or drawing number.
5. Total quantity used in instrument.
6. Recommended spare part quantity for complete maintenance during one year of isolated service.

Miscellaneous and mechanical parts not indexed by reference designation are listed at the end of the Table.

5-2 ORDERING INFORMATION

To order a replacement part, address your order or inquiry either to your local Hewlett-Packard/Dymec field office (listed on last page of this section) or to:

United States

Western Service Center
333 Logue Ave.
Mountain View, California 94040
Phone: (415) 968-9200
TWX: 910-379-6490

Eastern Service Center
Green Pond Road
Rockaway, New Jersey 07866
Phone: (201) 627-6400
TWX: 710-987-8461

Western Europe

Hewlett-Packard S.A.
54 Route des Acacias
1211 Geneva 24, Switzerland
Phone: (022) 42 81 50
TELEX: (845) 22-486

Specify the following information on each part:

1. Dymec model number and complete serial number of instrument.
2. ℗ stock number.
3. Circuit reference designation.
4. Description.

To order a part not listed in the Table, give complete description and include function and location of the part in the instrument and/or system.

5-3 ABBREVIATIONS USED

Reference Designation Column

A	= assembly	MP	= mechanical part
B	= motor	P	= plug
C	= capacitor	Q	= transistor
CR	= diode	R	= resistor
DL	= delay line	RT	= thermistor
DS	= device signaling (lamp)	RV	= varistor
E	= misc electronic part	S	= switch
F	= fuse	T	= transformer
FL	= filter	V	= vacuum tube, neon bulb, photocell, etc.
J	= jack		
K	= relay	W	= cable
L	= inductor	X	= socket
M	= meter	Z	= network

Description Column

a	= amperes	pos	= position(s)
c	= carbon	poly	= polystyrene
cer	= ceramic	pot	= potentiometer
comp	= composition	rect	= rectifier
depc	= deposited carbon	rot	= rotary
elect	= electrolytic	s-b	= slow-blow
f	= farads	Se	= selenium
f-a	= fast acting	sect	= section(s)
fxd	= fixed	Si	= silicon
Ge	= germanium	SPL	= special
incd	= incandescent	Ta	= tantalum
metflm	= metal film	Ti	= titanium dioxide
MFR	= manufacturer	tog	= toggle
my	= mylar	tol	= tolerance
NC	= normally closed	v	= volts
Ne	= neon	var	= variable
NFR	= not field replaceable	w/	= with
NO	= normally open	w	= watts
NPO	= zero temp coeff	ww	= wirewound
NSN	= no stock number	w/o	= without
NSR	= not separately replaceable	*	= optimum value selected, nominal value shown (component may be omitted)
OBD	= order by description		
pc	= printed circuit board		
piv	= peak inverse voltage		

5-4 RECOMMENDED INDUSTRIAL SPARES

In situations where down-time of the equipment is of critical importance, it is recommended that one of each of the following plug-in etched circuit boards or assemblies be stocked. This instrument can then be kept in operation while the faulty board or assembly is being repaired. The items listed without designation or stock number are for page number reference only.

Ref. Des.	Assembly Description	Stock No.	Page No.
2480A-A1	Etched Bd.	2480-6007	5-4
A2	AC Power Input	2480-6004	5-8
A1M1	Etched Bd.	2480-6019	5-8
A1M2	Etched Bd.	2480-6020	5-9
2480K-A1	Etched Bd.	2480-6011	5-10
2481A-A1	Relay Bd.	2481-6005	5-11
2481A-A2	Resistor Bd.	2481-6007	
2481A-M7	Relay Bd.	2481-6006	5-13
2482N-A1	Etched Bd.	2482-6002	5-14
2482N	Etched Bd.	2482-6003	

CIRCUIT REFERENCE	DESCRIPTION	STOCK NO.	MFR. CODE NO.	MFR. PART NO.	QTY.	1-YR. SPA.
	BASIC 2480A					
A1	Etched Bd	2480-6007	04404	-	1	0
A2	AC Power Input Bd	2480-6004	04404	-	1	0
R51	R: var, ww, 2K, 5%, 2 w, 10 tn	2100-1900	28480	-	1	0
T1	Transformer:	2480-8001	04404	-	1	1
	Miscellaneous					
	Case Assy	5060-6221	04404	-	1	
	Decal, knob	7120-1053	04404	-	1	
	Decal, name	7120-1063	04404	-	1	
	Decal, switch, pushbutton	7120-1080	04404	-	1	
	Decal, switch, push-pull	7120-1077	04404	-	1	
	Decal, switch, push-pull	7120-1088	04404	-	1	
	Knob, R51	5020-5178	04404	-	1	
	Panel, front	2480-4002	04404	-	1	
	Panel, rear	5040-1459	04404	-	1	
	Panel, sub	2480-0001	04404	-	1	
	Pushbutton, switch	5040-1461	04404	-	1	
	Push-pull button, switch	5040-1462	04404	-	1	
	A1 ETCHED BD.	2480-6007				
C1	C: fxd, al-elect, 800 µf, 65v	0180-1832	56289	(34D)D44173-DSB	1	1
C3, 4, 9	C: fxd, al-elect, 300 µf, -10 +75%, 40v	0180-1805	56289	34D307G040GJ2	3	1
C5, 6, 10	C: fxd, al-elect, 50 µf, -10 +100%, 25v	0180-0058	56289	30D506G025CC2-DSM	3	1
C7, 8, 11	C: fxd, my, .012 µf, 10%, 200v	0160-0301	28480	-	3	1
C12	C: fxd, mica, 1000 pf, 5%, 300v	0140-0152	04062	DM16F102J	1	1
C14	C: fxd, met-papr, 2 µf, 10%, 50v	0160-2572	56289	121P2059R5S4-PTM	1	1
C15, 19	C: fxd, al-elect, 20 µf, -10 +100%, 50v	0180-0049	56289	30D206G050CC2-DSM	2	1
C16, 17	C: fxd, my, .1 µf, 10%, 200v	0160-0168	28480	-	2	1
C18	C: fxd, mica, 470 pf, 5%, 300v	0160-2210	28480	-	1	1
CR1-12, 20	Diode: Si, rect	1901-0158	28480	-	13	4
CR15, 16, 18, 19, 23	Diode: Si	1901-0025	28480	-	5	3
CR17	Diode: avalanche, Si	1902-0112	CS000	-	1	1
CR21, 22	Diode: avalanche, 17.8v	1902-3224	28480	-	2	2
CR24	Diode: avalanche, 20v	1902-3237	28480	-	1	2
J1	Conn: pc, 20 pin	1251-1671	95238	OBD	1	1
Q1	Transistor: Si, NPN	1854-0039	02735	2N3053	1	1
Q2, 18	Transistor: Si, NPN	1854-0003	28480	-	2	1
Q3	Transistor: Si, PNP	1853-0001	28480	-	1	1
Q4	Transistor: Si, PNP	1853-0027	28480	-	1	1
Q5A/B, 15A/B	Transistor: Dual (.4w ea), Si, NPN	1854-0221	28480	-	2	1
Q6	Transistor: Si, NPN	1854-0209	01295	2N910	1	1
Q7A/B	Transistor: Dual, Si, PNP	1853-0032	28480	-	1	1

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CIRCUIT REFERENCE	DESCRIPTION	STOCK NO.	MFR. CODE NO.	MFR. PART NO.	QTY.	1-YR. SPA.
Q9	Transistor: Si, PNP	1853-0010	28480	-	1	1
Q10, 11, 13, 19	Transistor: Si, NPN	1854-0022	28480	-	4	1
Q12	Transistor: Si, PNP	1853-0037	28480	-	1	1
Q14	Transistor: Si, NPN, JEDEC 2N3767	1854-0227	28480	-	1	1
Q16, 17	Transistor: Si, NPN	1854-0045	28480	-	2	1
R1, 2	R: fxd, metflm, 1.2K, 2%, 1/8 w	0757-0926	28480	-	2	1
R3, 4	R: fxd, comp, 12Ω, 5%, 1/4 w	0683-1205	28480	-	2	1
R5, 6	R: fxd, metflm, 3.3K, 2%, 1/8 w	0757-0936	28480	-	2	1
R7	R: fxd, ww, 9K, 1%, 1/4 w	0811-2002	28480	-	1	1
R8	R: fxd, ww, 2K, 1%, 1/4 w	0811-1769	28480	-	1	1
R9	R: fxd, metflm, 1.5K, 1%, 1/4 w	0698-5523	28480	-	1	1
R10, 11, 19, 20, 25, 29, 46, 47, 53	R: fxd, metflm, 100Ω, 2%, 1/8 w	0757-0900	28480	-	9	2
R12, 13, 44, 45	R: fxd, metflm, 20K, 2%, 1/8 w	0757-0955	28480	-	4	1
R14	R: fxd, metflm, 18K, 2%, 1/8 w	0757-0954	28480	-	1	1
R15, 27, 28	R: fxd, metflm, 3K, 2%, 1/8 w	0757-0935	28480	-	3	1
R16, 17	R: fxd, metflm, 30K, 2%, 1/8 w	0757-0959	28480	-	2	1
R18	R: fxd, metflm, 5.6K, 2%, 1/8 w	0757-0942	28480	-	1	1
R22	R: fxd, metflm, 36K, 2%, 1/8 w	0757-0961	28480	-	1	1
R23	R: fxd, metflm, 680Ω, 2%, 1/8 w	0757-0920	28480	-	1	1
R24	R: fxd, metflm, 300Ω, 2%, 1/8 w	0757-0911	28480	-	1	1
R26, 42	R: fxd, metflm, 27K, 2%, 1/8 w	0757-0958	28480	-	2	1
R30	R: fxd, metflm, 4.7K, 2%, 1/8 w	0757-0940	28480	-	1	1
R31	R: fxd, metflm, 16K, 2%, 1/8 w	0757-0953	28480	-	1	1
R32	R: fxd, metflm, 1K, 2%, 1/8 w	0757-0924	28480	-	1	1
R33	R: fxd, metflm, 360Ω, 2%, 1/8 w	0757-0913	28480	-	1	1
R34, 35	R: fxd, comp, 5.1K, 5%, 1/2 w	0686-5125	28480	-	2	1
R36	R: var, ww, 500Ω, 5%, 1 w	2100-0898	28480	-	1	0
R37, 56	R: fxd, ww, 10Ω, 5%, 2 w	0811-1767	28480	-	2	1
R38	R: fxd, metflm, 1K, 2%, 1/8 w	0757-0924	28480	-	1	1
R39	R: fxd, ww, 30Ω, 1%, 2 w	0811-1768	28480	-	1	1
R40	R: fxd, metflm, 3010Ω, 1%, 1/4 w	0698-5156	28480	-	1	1
R41	R: fxd, metflm, 2K, 1%, 1/4 w	0698-5155	28480	-	1	1
R43	R: fxd, metflm, 15K, 2%, 1/8 w	0757-0952	28480	-	1	1
R48, 57	R: fxd, metflm, 6.8K, 2%, 1/8 w	0757-0944	28480	-	2	1
R49	R: fxd, metflm, 4.3K, 2%, 1/8 w	0757-0939	28480	-	1	1
R50	R: fxd, metflm, 866Ω, 1%, 1/4 w	0698-5154	28480	-	1	1
R52	R: fxd, cflm, 1.21K, 1%, 1/2 w	0727-0755	28480	-	1	1
R54	R: fxd, comp, 8.2K, 5%, 1/2 w	0686-8225	28480	-	1	1
R58	R: fxd, metflm, 100K, 2%, 1/8 w	0757-0972	28480	-	1	1
S1A-D, 2A-F, 3A-H, 5A/B	Switch: slide, DPDT, 0.5a	3101-0070	79727	126B	10	1

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CIRCUIT REFERENCE	DESCRIPTION	STOCK NO.	MFR. CODE NO.	MFR. PART NO.	QTY.	1-YR. SPA.
	A2 POWER INPUT BD	2480-6004				
C20, 21	C: fxd, cer, .002 μf, 20%, 1000v	0150-0023	8441	type 126	2	1
F1	Fuse: 1a	2110-0047	28480	-	1	5
L1, 2	Inductor: RF, coil, fxd, 15 μh	9140-0082	95265	NA-15.0-I	2	1
S6	Switch: slide, DPDT, .5a/125v, AC-DC	3101-0973	79727	6934	1	0
	2480A-M1, 2 Refer 2480A Table of Replaceable Parts except as follows:					
	M1: Delete: A1 Add:					
A1	Etched Bd. Ref Std. A1 (2480-6007) Parts List except as follows:	2480-6019	04404	-	1	0
	Add:					
R21	R: fxd, metflm, 2M, 1%, 1/2 w	0698-5539	28480	-	1	1
R55	R: var, ww, 10K, 10%, 1 w	2100-1660	28480	-	1	0
	Miscellaneous Decal "M1"	7120-1911	04404	-	1	0
	M2: Delete: A1; R51 Add:					
A1	Etched Board	2480-6020	04404	-	1	0
R51	R: var, ww, 10K, 5%, 3/4 w	2100-1999	28480	-	1	0
	A1 ETCHED BD. Ref. Std. A1 (2480-6007) Parts List except as follows:	2480-6020				
	Delete: R9 Add:					
R9	R: fxd, metflm, 383K, 1%, 1/2 w	0757-0133	28480	-	1	1
R21	R: fxd, metflm, 1.5K, 1%, 1/4 w	0698-5523	28480	-	1	1
R55	R: var, ww, 2K, 10%, 1 w	2100-1658	28480	-	1	0
	A1-Miscellaneous Decal "M2"	7120-1912	28480	-		

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CIRCUIT REFERENCE	DESCRIPTION	STOCK NO.	MFR. CODE NO.	MFR. PART NO.	QTY.	1-YR. SPA.
	BASIC 2480K EXCITATION COUPLER					
A1	Etched Bd.	2480-6011	04404	-	1	0
	Ref. 2480A list except as follows:					
	Delete: Decal, name; Knob; Panel, front, Pushbutton, push-pull					
	Add:					
	Decal, name	7120-1061	04404	-	1	
	Decal, overlay, left	7120-1922	04404	-	1	
	Panel, front	2480-4004	04404	-	1	
	A1 ETCHED BD.	2480-6011				
J1	Conn: pc, 20 pin	1251-1671	95238	OBD	1	1
S1A/B, S2A-11	Switch: slide, DPDT, 0.5a	3101-0070	79727	126B	5	1

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CIRCUIT REFERENCE	DESCRIPTION	STOCK NO.	MFR. CODE NO.	MFR. PART NO.	QTY.	1-YR. SPA.
	BASIC 2481A RESISTANCE BRIDGE					
A1	Relay Bd.	2481-6005	04404	-	1	0
A2	Resistor Bd.	2481-6007	04404	-	1	0
A3	Coupler Bd.	2481-8001	04404	-	1	0
	Miscellaneous					
	Button, push	5040-1461	04404	-	3	
	Insert, knob	7120-1054	04404	-	1	
	Knob, R16	5020-5178	04404	-	1	
	Decal, name	7120-1058	04404	-	1	
	Decal, pushbutton	7120-1080	04404	-	1	
	Decal, pushbutton	7120-1082	04404	-	1	
	Decal, pushbutton	2481-4005	04404	-	1	
	Panel	2481-4005	04404	-	1	
	Panel, sub, upper	2480-0001	04404	-	1	
	A1 RELAY BD.	2481-6005				
CR1, 2, 13, 14	Diode: Si	1901-0025	28480	-	4	3
J1	Conn: pc, 20 pin	1251-1671	95238	OBD	1	1
J2	Conn: pc, 48 pin	1251-0497	28480	-	1	1
K1	Relay: reed, 2A, 4K, 24v	0490-0322	02116*	262-2A-24	1	1
R16	R: var, ww, 10K, 5%, 3/4 w, 10 tn	2100-1999	28480	-	1	0
S1, 2, 3A-D, 4, 5, 6A/B	Switch: slide, DPDT, 0.5a	3101-0070	79727	126B	7	1
	2481A-M1-5 Ref. 2481A Table of Replaceable Parts except as follows: Add: as noted					
A1CR3-12	Diode: Si	1901-0025	28480	-	2/MOD	4
A1K2-6	Relay: reed, 2A, 4K, 24v	0490-0322	02116	262-2A-24	1/MOD	5
	A1 Miscellaneous					
	Decal, "M1" thru "M5"	7120-1911 thru -1915	04404	-		
	Decal, Relay-overlay (for M1, 2, 5)	2481-0002	04404	-		
	Decal, Relay-overlay (for M3-5)	2481-0003	04404	-		
	2481A-M6 Ref. 2481A Table of Replaceable Parts except as follows: Delete: Panel, upper Add:					
	Main Chassis: Miscellaneous					
	Decal, Knob, M6	7120-1083	04404	-	1	
	Decal, Knob, M1-5, consecutively (w/stk. nos. as shown):	7120-1084 thru -1087	04404	-		
		7120-1050	04404	-		
	Knob, Switch	2402-2040	04404	-	1	
	Panel, upper	2481-4002	04404	-	1	

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*Not on Mfr. Code List: 02116; Wheelock Signals, Inc., Long Branch, New Jersey

CIRCUIT REFERENCE	DESCRIPTION	STOCK NO.	MFR. CODE NO.	MFR. PART NO.	QTY.	1-YR. SPA.
	A1: as noted					
A1S7	Switch: rotary, 1P7Pos	3100-1411	28480	-	1	1
	A1 Miscellaneous					
	Decal, "M6"	7120-1916	04404	-	1	
	2481A-M7 Ref 2481A Table of Replaceable Parts except as follows:					
	Delete: A1 Add:					
A1	Relay Bd. (Ref. Std A1 (2481-6005) Parts List except as follows:	2481-6006	04404	-	1	0
	Add:					
CR5-8	Diode: Si	1901-0025	28480	-	4	3

MO183

CIRCUIT REFERENCE	DESCRIPTION	STOCK NO.	MFR. CODE NO.	MFR. PART NO.	QTY.	1-YR. SPA.
	BASIC 2482N MONITOR FUNCTION SELECTOR					
A1	Etched Bd., selector	2482-6002	04404	-	1	0
A2	Etched Bd., jumper	2482-6003	04404	-	1	0
	Miscellaneous					
	Case Assy	5060-6221	04404	-	1	
	Decal, Knob	7120-0151	04404	-	1	
	Decal, name	7120-1065	04404	-	1	
	Knob, S1	2402-2040	04404	-	1	
	Panel, Lower	2480-4001	04404	-	1	
	Panel, Rear	5040-1459	04404	-	1	
	Panel, Sub	2481-0001	04404	-	1	
	Panel, Upper	2481-4004	04404	-	1	
	A1 SELECTOR BD	2482-6002				
J2	Conn: pc, 48 pin	1251-0497	28480	-	1	1
R1	R: fxd, ww, 1Ω, .002%, 1 w	0811-2145	28480	-	1	1
S1	Switch: rotary, 4P4Pos	3100-1415	28480	-	1	0

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CODE LIST OF MANUFACTURERS

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 Handbooks.

Code No.	Manufacturer	Address
00000	U.S.A. Common	Any supplier of U.S.
00136	McCoy Electronics	Mount Holly Springs, Pa.
00213	Sage Electronics Corp.	Rochester, N.Y.
00287	Cemco Inc.	Danielson, Conn.
00334	Humidial	Colton, Calif.
00348	Microtron Co., Inc.	Valley Stream, N.Y.
00373	Garlock Inc., Electronics Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp. Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.
00853	Sangamo Electric Co., Pickens Div.	Pickens, S.C.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
00929	Microlab Inc.	Livingston, N.J.
01002	General Electric Co., Capacitor Dept.	Hudson Falls, N.Y.
01009	Alden Products Co.	Brockton, Mass.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	TRW Semiconductors, Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc., Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01930	Amerock Corp.	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02116	Wheelock Signals, Inc.	Long Branch, N.J.
02286	Cole Rubber and Plastics Inc.	Sunnyvale, Calif.
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America, Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Prod. Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	Compton, Calif.
03877	Transitron Electric Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co., Inc.	Cedar Knolls, N.J.
03954	Singer Co., Diehl Div. Finderne Plant	Sumerville, N.J.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04013	Taurus Corp.	Lambertville, N.J.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04354	Precision Paper Tube Co.	Chicago, Ill.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Products, Microwave Device Div.	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc. Western Div.	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04796	Sequoia Wire Co.	Redwood City, Calif.
04811	Precision Coil Spring Co.	El Monte, Calif.
04870	P.M. Motor Company	Westchester, Ill.
04919	Component Mfg. Service Co.	W. Bridgewater, Mass.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp. Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Calif.
05397	Union Carbide Corp., Linde Div., Kemet Dept.	Cleveland, Ohio
05593	Illumitronic Engineering Co.	Sunnyvale, Calif.
05616	Cosmo Plastic (c/o Electrical Spec. Co.)	Cleveland, Ohio
05624	Barber Colman Co.	Rockford, Ill.
05728	Tiffen Optical Co.	Roslyn Heights, Long Island, N.Y.
05729	Metro-Tel Corp.	Westbury, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
05820	Wakefield Engineering Inc.	Wakefield, Mass.
06004	Bassick Co., The	Bridgeport, Conn.
06090	Raychem Corp.	Redwood City, Calif.
06175	Bausch and Lomb Optical Co.	Rochester, N.Y.
06402	E.T.A. Products Co. of America	Chicago, Ill.
06540	Amatom Electronic Hardware Co., Inc.	New Rochelle, N.Y.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06666	General Devices Co., Inc.	Indianapolis, Ind.
06751	Semcor Div. Components Inc.	Phoenix, Ariz.
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
06980	Varian Assoc. Eimac Div.	San Carlos, Calif.
07088	Kelvin Electric Co.	Van Nuys, Calif.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07149	Filmohm Corp.	New York, N.Y.
07233	Cinch-Graphik Co.	City of Industry, Calif.
07261	Avnet Corp.	Culver City, Calif.
07263	Fairchild Camera & Inst. Corp. Semiconductor Div.	Mountain View, Calif.
07322	Minnesota Rubber Co.	Minneapolis, Minn.
07387	Birtcher Corp., The	Monterey Park, Calif.
07397	Sylvania Elect. Prod. Inc., Mt. View Operations	Mountain View, Calif.
07700	Technical Wire Products Inc.	Cranford, N.J.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Raytheon Mfg. Co., Semiconductor Div.	Mountain View, Calif.
07980	Hewlett-Packard Co., Boonton Radio Div.	Rockaway, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08289	Blinn, Delbert Co.	Pomona, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada
08524	Deutsch Fastener Corp.	Los Angeles, Calif.
08664	Bristol Co., The	Waterbury, Conn.
08717	Sloan Company	Sun Valley, Calif.
08718	ITT Cannon Electric Inc., Phoenix Div.	Phoenix, Arizona
08792	CBS Electronics Semiconductor Operations, Div of C.B.S. Inc.	Lowell, Mass.
08984	Mel-Rain	Indianapolis, Ind.
09026	Babcock Relays Div.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09145	Atohm Electronics	Sun Valley, Calif.
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
10214	General Transistor Western Corp.	Los Angeles, Calif.
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11242	Bay State Electronics Corp.	Waltham, Mass.
11312	Teledyne Inc., Microwave Div.	Palo Alto, Calif.
11534	Duncan Electronics Inc.	Costa Mesa, Calif.
11711	General Instrument Corp., Semiconductor Div., Products Group	Newark, N.J.
11717	Imperial Electronic, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12136	Philadelphia Handle Co.	Camden, N.J.
12361	Grove Mfg. Co., Inc.	Shady Grove, Pa.
12574	Gulton Ind. Inc., CG Elect. Div.	Albuquerque, N.M.
12697	Clarostat Mfg. Co.	Dover, N.H.
12728	Elmar Filter Corp.	W. Haven, Conn.
12859	Nippon Electric Co., Ltd.	Tokyo, Japan
12881	Metex Electronics Corp.	Clark, N.J.
12930	Delta Semiconductor Inc.	Newport Beach, Calif.
12954	Dickson Electronics Corp.	Scottsdale, Arizona
13103	Thermolloy	Dallas, Texas
13396	Telefunken (GmbH)	Hanover, Germany
13835	Midland-Wright Div. of Pacific Industries, Inc.	Kansas City, Kansas
14099	Sem-Tech	Newbury Park, Calif.
14193	Calif. Resistor Corp.	Santa Monica, Calif.
14298	American Components, Inc.	Conshohocken, Pa.
14433	ITT Semiconductor, A Div. of Int. Telephone & Telegraph Corp.	West Palm Beach, Fla.
14493	Hewlett-Packard Company	Loveland, Colo.
14655	Cornell Dublier Electric Corp.	Newark, N.J.
14674	Corning Glass Works	Corning, N.Y.
14752	Electro Cube Inc.	So. Pasadena, Calif.
14960	Williams Mfg. Co.	San Jose, Calif.
15203	Webster Electronics Co.	New York, N.Y.
15287	Scionics Corp.	Northridge, Calif.
15291	Adjustable Bushing Co.	N. Hollywood, Calif.
15558	Micron Electronics	Garden City, Long Island, N.Y.
15566	Amprobe Inst. Corp.	Lynbrook, N.Y.
15631	Cabletronics	Costa Mesa, Calif.
15772	Twentieth Century Coil Spring Co.	Santa Clara, Calif.
15818	Ameico Inc.	Mt. View, Calif.
15909	Daven Div. Thomas A. Edison Ind. McGraw-Edison Co.	Long Island City, N.Y.
16037	Spruce Pine Mica Co.	Spruce Pine, N.C.
16179	Omni-Spectra Inc.	Detroit, Ill.
16352	Computer Diode Corp.	Lodi, N.J.
16688	Ideal Prec. Meter Co., Inc. De Jur Meter Div.	Brooklyn, N.Y.
16758	Delco Radio Div. of G.M. Corp.	Kokoma, Ind.
17109	Thermonetics Inc.	Canoga Park, Calif.
17474	Tranex Company	Mountain View, Calif.
17675	Hamlin Metal Products Corp.	Akron, Ohio
17745	Angstrohm Prec. Inc.	No. Hollywood, Calif.
18042	Power Design Pacific Inc.	Palo Alto, Calif.
18083	Clevite Corp., Semiconductor Div.	Palo Alto, Calif.
18476	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
18486	TRW Elect. Comp. Div.	Des Plaines, Ill.
18583	Curtis Instrument, Inc.	Mt. Kisco, N.Y.
18873	E.I. DuPont and Co., Inc.	Wilmington, Del.
18911	Durant Mfg. Co.	Milwaukee, Wis.
19315	Bendix Corp., The Eclipse-Poineer Div.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19589	Concoa	Baldwin Park, Calif.
19644	LRC Electronics	Horseheads, N.Y.
19701	Electra Mfg. Co.	Independence, Kansas
20183	General Atronics Corp.	Philadelphia, Pa.
21226	Executone, Inc.	Long Island City, N.Y.

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CODE LIST OF MANUFACTURERS (Cont'd)

Code No.	Manufacturer	Address
21335	Fafnir Bearing Co., The	New Britain, Conn.
21520	Fansteel Metallurgical Corp.	N. Chicago, Ill.
23783	British Radio Electronics Ltd.	Washington, D.C.
24455	G.E. Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26365	Gries Reproducer Corp.	New Rochelle, N.Y.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
28520	Heyman Mfg. Co.	Kenilworth, N.J.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
36196	Stanwyck Coil Products Ltd.	Hawkesbury, Ontario, Canada
36287	Cunningham, W.H. & Hill, Ltd.	Toronto Ontario, Canada
37942	P.R. Mallory & Co. Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C.A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
46384	Penn Eng. & Mfg. Corp.	Doylestown, Pa.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer & Inst. Co.	Southampton, Pa.
49956	Microwave & Power Tube Div.	Waltham, Mass.
52090	Rowan Controller Co.	Westminster, Md.
52983	Sanborn Company	Waltham, Mass.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Raytheon Co. Commercial Apparatus & Systems Div.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
59730	Thomas & Betts Co.	Elizabeth, N.J.
60741	Triplett Electrical Inst. Co.	Bluffton, Ohio
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Pittsburgh, Pa.
62119	Universal Electric Co.	Owosso, Mich.
63743	Ward-Leonard Electric Co.	Mt. Vernon, N.Y.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Inc. Weston-Newark	Newark, N.J.
66295	Wittek Mfg. Co.	Chicago, Ill.
66346	Revere Wollansak Div. Minn. Mining & Mfg. Co.	St. Paul, Minn.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control	New York, N.Y.
70318	Allmetal Screw Product Co., Inc.	Garden City, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	Union City, N.J.
70674	ADC Products Inc.	Minneapolis, Minn.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio, Inc.	Willoughby, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Cardwell Condenser Corp.	Lindenhurst L.I., N.Y.
71400	Bussmann Mfg. Div. of McGraw-Edison Co.	St. Louis, Mo.
71436	Chicago Condenser Corp.	Chicago, Ill.
71447	Calif. Spring Co., Inc.	Pico-Rivera, Calif.
71450	CTS Corp.	Elkhart, Ind.
71468	ITT Cannon Electric Inc.	Los Angeles, Calif
71471	Cinema, Div. Aerovox Corp.	Burbank, Calif.
71482	C.P. Clare & Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71616	Commercial Plastics Co.	Chicago, Ill.
71700	Cornish Wire Co., The	New York, N.Y.
71707	Coto Coil Co., Inc.	Providence, R.I.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A.O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Co., Howard B. Jones Div.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72354	John E. Fast Co., Div. Victoreen Instr. Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	Indiana General Corp., Electronics Div.	Keasby, N.J.
72699	General Instrument Corp., Cap. Div.	Newark, N.J.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72964	Robert M. Hadley Co.	Los Angeles, Calif.
72982	Erie Technological Products, Inc.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73076	H.M. Harper Co.	Chicago, Ill.
73138	Helipot Div. of Beckman Inst., Inc.	Fullerton, Calif.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co., Inc.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73586	Circle F Mfg. Co.	Trenton, N.J.
73682	George K. Garrett Co., Div. MSL Industries Inc.	Philadelphia, Pa.
73734	Federal Screw Products Inc.	Chicago, Ill.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	General Industries Co., The	Elyria, Ohio
73846	Goshen Stamping & Tool Co.	Goshen, Ind.
73899	JFD Electronics Corp.	Brooklyn, N.Y.
73905	Jennings Radio Mfg. Corp.	San Jose, Calif.
74276	Signalite Inc.	Neptune, N.J.
74455	J.H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75378	CTS Knights Inc.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littlefuse, Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C.W. Marwedel	San Francisco, Calif.
76433	General Instrument Corp., Micamold Division	Newark, N.J.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J.W. Miller Co.	Los Angeles, Calif.
76530	Cinch-Monadnock, Div. of United Carr Fastener Corp.	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76703	National Union	Newark, N.J.
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	Bendix Corp., The Bendix Pacific Div.	N. Hollywood, Calif.
77075	Pacific Metals Co.	San Francisco, Calif.
77221	Phanostran Instrument and Electronic Co.	South Pasadena, Calif.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	American Machine & Foundry Co. Potter & Brumfield Div.	Princeton, Ind.
77630	TRW Electronic Components Div.	Camden, N.J.
77638	General Instrument Corp., Rectifier Div.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
77969	Rubbercraft Corp. of Calif.	Torrance, Calif.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78283	Signal Indicator Corp.	New York, N.Y.
78290	Struthers-Dunn Inc.	Pitman, N.J.
78452	Thompson-Bremer & Co.	Chicago, Ill.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78493	Standard Thomson Corp.	Waltham, Mass.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	San Gabriel, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79136	Waldes Kohinoor Inc.	Long Island City, N.Y.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80120	Schnitzer Alloy Products Co.	Elizabeth, N.J.
80131	Electronic Industries Association. Any brand Tube meeting EIA Standards-Washington, DC.	
80207	Unimax Switch, Div. Maxon Electronics Corp.	Wallingford, Conn.
80223	United Transformer Corp.	New York, N.Y.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Inc.	Riverside, Calif.
80411	Acro Div. of Robertshaw Controls Co.	Columbus, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80509	Avery Adhesive Label Corp.	Monrovia, Calif.
80583	Hammarlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments Inc.	Orange, Conn.
81073	Grayhill Co.	LaGrange, Ill.
81095	Triad Transformer Corp.	Venice, Calif.
81312	Winchester Elec. Div. Litton Ind., Inc.	Oakville, Conn.
81349	Military Specification	. . . .
81483	International Rectifier Corp.	El Segundo, Calif.
81541	Airpax Electronics, Inc.	Cambridge, Mass.
81860	Barry Controls, Div. Barry Wright Corp.	Watertown, Mass.
82042	Carter Precision Electric Co.	Skokie, Ill.
82047	Sperti Faraday Inc., Copper Hewitt Electric Div.	Hoboken, N.J.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Fairchild Camera & Inst. Corp., Defense Prod. Division	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc. Electronic Tube Division	Emporium, Pa.
82376	Astron Corp.	East Newark, Harrison, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals & Controls Inc. Spencer Products	Attleboro, Mass.
82768	Phillips-Advance Control Co.	Joliet, Ill.

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CODE LIST OF MANUFACTURERS (Cont'd)

Code No.	Manufacturer	Address
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Mfg. Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83053	Western Washer Mfg. Co.	Los Angeles, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	General Instrument Corp., Capacitor Div.	Darlington, S.C.
83148	ITT Wire and Cable Div.	Los Angeles, Calif.
83186	Victory Eng. Corp.	Springfield, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83315	Hubbell Corp.	Mundelein, Ill.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83332	Tech Labs	Palisade's Park, N.J.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Co. Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp. Electronic Tube Div.	Plainfield, N.J.
83740	Union Carbide Corp. Consumer Prod. Div.	New York, N.Y.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
83942	Aeronautical Inst. & Radio Co.	Lodi, N.J.
84171	Arco Electronics Inc.	Great Neck, N.Y.
84396	A.J. Glesener Co., Inc.	San Francisco, Calif.
84411	TRW Capacitor Div.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85471	A.B. Boyd Co.	San Francisco, Calif.
85474	R.M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	Hamden, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86197	Clifton Precision Products Co., Inc.	Clifton Heights, Pa.
86579	Precision Rubber Products Corp.	Dayton, Ohio
86684	Radio Corp. of America, Electronic Comp. & Devices Div.	Harrison, N.J.
87034	Marco Industries	Anaheim, Calif.
87216	Philco Corporation (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
87664	Van Waters & Rogers Inc.	San Francisco, Calif.
87930	Tower Mfg. Corp.	Providence, R.I.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
88421	Federal Telephone & Radio Corp.	Clifton, N.J.
88698	General Mills, Inc.	Buffalo, N.Y.
89231	Graybar Electric Co.	Oakland, Calif.
89665	United Transformer Co.	Chicago, Ill.
90179	US Rubber Co., Consumer Ind. & Plastics Prod. Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91146	ITT Cannon Elect, Inc.,	Salem Div. Salem, Mass.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91345	Miller Dial & Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Willow Grove, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91886	Malco Mfg. Co., Inc.	Chicago, Ill.
91929	Honeywell Inc., Micro Switch Div.	Freeport Ill.
91961	Nahm-Bros. Spring Co.	Oakland, Calif.
92180	Tru-Connector Corp.	Peabody, Mass.
92367	Elgeet Optical Co. Inc.	Rochester, N.Y.
92196	Universal Industries, Inc.	City of Industry, Calif.
92607	Tensolite Insulated Wire Co., Inc.	Tarrytown, N.Y.
92702	IMC Magnetics Corp.	Wesbury Long Island, N.Y.
92966	Hudson Lamp Co.	Kearney, N.J.
93332	Sylvania Electric Prod. Inc. Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93929	G.V. Controls	Livingston, N.J.
94137	General Cable Corp.	Bayonne, N.J.
94144	Raytheon Co., Comp. Div., Ind. Comp. Operations	Quincy, Mass.
94148	Scientific Electronics Products, Inc.	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp. Electronics Div.	East Paterson, N.J.
94222	South Chester Corp.	Chester, Pa.
94310	Tru-Ohm Products Memcor Components Div.	Huntington, Ind.
94330	Wire Cloth Products, Inc.	Bellwood, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
94696	Magnecraft Electric Co.	Chicago, Ill.
95023	George A. Philbrick Researchers, Inc.	Boston, Mass.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	Long Island, N.Y.
95264	Lerco Electronics, Inc.	Burbank, Calif.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95348	Gordos Corp.	Bloomfield, N.J.
95354	Methode Mfg. Co.	Chicago, Ill.
95566	Arnold Engineering Co.	Marengo, Ill.
95712	Dage Electric Co., Inc.	Franklin, Ind.
95984	Siemon Mfg. Co.	Wayne, Ill.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Div. of Aerovox Corp.	Olean, N.Y.
96256	Thordarson-Meissner Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic & Precision Mfg.	Englewood, N.J.
97979	Reon Resistor Corp.	Yonkers, N.Y.
97983	Litton System Inc., Adler-Westrex Commun. Div.	New Rochelle, N.Y.
98141	R-Troncis, Inc.	Jamaica, N.Y.
98159	Rubber Teck, Inc.	Gardena, Calif.
98220	Hewlett-Packard Co., Moseley Div.	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98376	Zero Mfg. Co.	Burbank, Calif.
98731	General Mills Inc., Electronics Div.	Minneapolis, Minn.
98734	Paeco Div. of Hewlett-Packard Co.	Palo Alto, Calif.
98821	North Hills Electronics, Inc.	Glen Cove, N.Y.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99378	Atlee Corp.	Winchester, Mass.
99515	Marshall Ind. Elect. Products Div.	San Marino, Calif.
99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Electronics Corp. Semiconductor Div.	El Monte, Calif.
99957	Technology Instrument Corp. of Calif.	Newbury Park, Calif.

THE FOLLOWING HP VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

0000F	Malco Tool and Die	Los Angeles, Calif.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AB	ETA	England
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000CS	Hewlett-Packard Co., Colorado Springs	Colorado Springs, Colorado
000MM	Rubber Eng. & Development	Hayward, Calif.
000NN	A "N" D Mfg. Co.	San Jose, Calif.
000QQ	Cooltron	Oakland, Calif.
000WW	California Eastern Lab.	Burlington, Calif.
000YY	S.K. Smith Co.	Los Angeles, Calif.

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HEWLETT hp PACKARD

ELECTRONIC INSTRUMENTATION SALES AND SERVICE

UNITED STATES

ALABAMA
P.O. Box 4207
2003 Byrd Spring Road S.W.
Huntsville 35802
Tel: (205) 881-4591
TWX: 810-726-2204

ARIZONA
3009 North Scottsdale Road
Scottsdale 85251
Tel: (602) 945-7601
TWX: 910-950-1282

232 South Tucson Boulevard
Tucson 85716
Tel: (602) 623-2564
TWX: 910-952-1162

CALIFORNIA
3939 Lankershim Boulevard
North Hollywood 91604
Tel: (213) 877-1282
TWX: 910-499-2170

1101 Embarcadero Road
Palo Alto 94303
Tel: (415) 327-6500
TWX: 910-373-1280

2591 Carlsbad Avenue
Sacramento 95821
Tel: (916) 482-1463
TWX: 910-367-2092

1055 Shafter Street
San Diego 92106
Tel: (714) 223-8103
TWX: 910-335-2000

COLORADO
7965 East Prentice
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APPENDIX A
to
PRELIMINARY MANUAL
for

2480 SERIES
SIGNAL CONDITIONING
EQUIPMENT

DYMEC
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MODEL 2480C
EXCITATION COUPLER

A-1 ELECTRICAL DESCRIPTION

This appendix to the Prelininary Manual for the Model 2480 Series Signal Conditioning Equipment covers a modular unit, the HP-2480C Excitation Coupler, shown in Figure A-1.

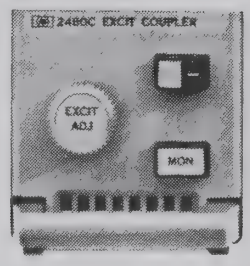

Figure A-1 HP-2480C Excitation Coupler, Front View

The HP-2480C's require an external source of 28 volt dc power. The capacity of this external master power supply determines how many HP-2480C's may be powered. Typically an HP-6265A Power Supply has sufficient capacity for supplying power to approximately 40 HP-2480C's. When operated in the constant voltage mode, each HP-2480C provides an adjustable excitation output voltage of 1.0 to 12 volts to the HP-2481A resistance bridge at a maximum current of 40 ma. When operated in the constant current mode, the HP-2480C provides an adjustable excitation output current of 5.0 to 40 ma with a maximum compliance of 6 volts.

The excitation output leads to the transducer may be shorted over an extended period with no damage to the instrument. Normal operation resumes upon removal of the short. All circuits are shielded and guarded. The HP-2480C has no provision for remote sensing.

A-2. PHYSICAL DESCRIPTION

The outward appearance of the HP-2480C is identical to that of the HP-2480A. Comparing Figure A-2 with Figure 1-2 of the manual reveals that within the HP-2480C there is no transformer or ac input board A2 and its etched circuit board A1 contains considerably fewer components than that of the HP-2480A.

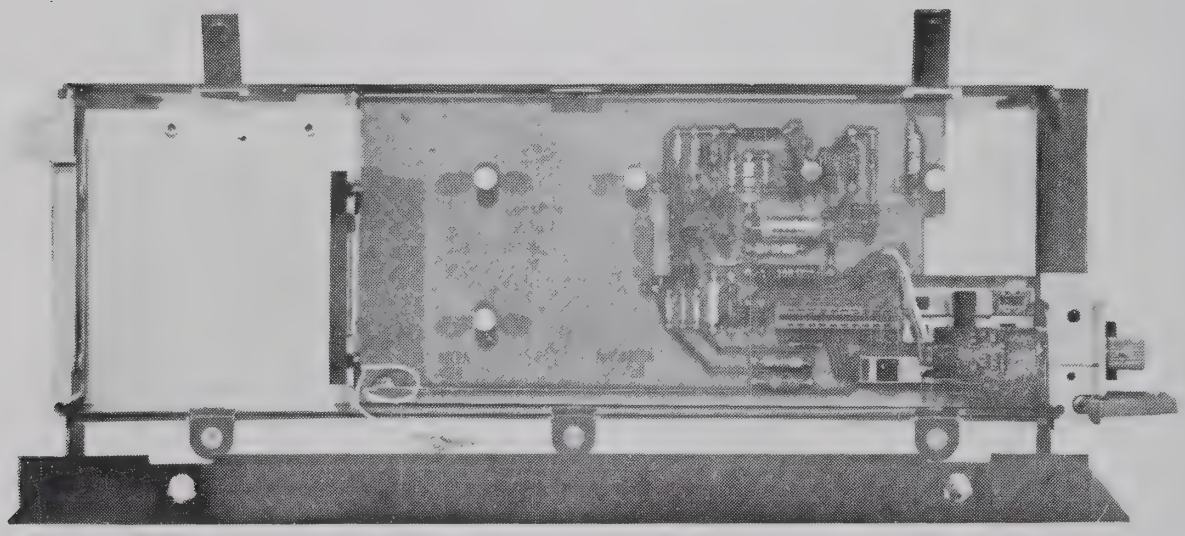

Figure A-2 HP-2480C Excitation Coupler, Internal View

A-3 SPECIFICATIONS

Performance specifications for the HP-2480C are provided. The 28 vdc master power supply should have performance specifications equal to or better than an HP-6265A.

Parameter	Constant Voltage Mode	Constant Current Mode
Output Voltage,	1.0 to 12.0 volts	-
Output Current,	0 to 40 mA	5 to 40mA
Compliance	-	0 to 6 volts
Allowable Transducer Resistance	50Ω minimum	0 to 1200Ω
Temperature Coefficient of Output	1.5mV/°C+0.05%/°Cof output voltage	10μA/°C+0.5%/°Cof output current
Load Regulation	30mV +0.08% of output voltage reading for a load current change of 40mA	150μA for a resistive load change of 10% at load current of 40mA
Transient response to within 0.01% of static regulation point	5mS no load to full load	5mS for a load change of 10%
Thermal Noise 0 to 40Kc bandwidth	450μV rms	3μA rms
Output Voltage change for a 1 volt change in 28 volt master power supply	50mV	300μA
Output Resolution	.05%	.05%
Short Circuit Protection Limits at 70±20 output	Output may be shorted indefinitely with no damage to instrument	Output may be open or shorted indefinitely with no damage to instrument
Transducer Cable Resistance	Loop resistance 20Ω maximum	Loop resistance 20Ω maximum
Remote Sensing	None	None
Guarded Capacity	20pf measured in 12521A combining case. (Value shown does not include contribution of 28 volt master power supply)	Same
Power Requirements	28V ±5% 30 ma + delivered load current	Same

SPECIFICATIONS (Cont'd)

Parameter	Constant Voltage Mode	Constant Current Mode
Polarity Reversal Switch	Yes	Yes
Turn on-off transient	3V peak Max., energy <100mW seconds	Same
GENERAL SPECIFICATIONS:	Environmental: Operating: 0 to +55°C Non-Operating: -40 to +75°C Relative humidity to 95% + 25 to +40°C Altitude: 15, 000 feet operating; 25, 000 feet non-operating.	

A-4 INSTALLATION

Up to ten HP-2480C's may be accommodated in an HP-12521A Combining Case. Additional combining cases may be interconnected as described in Section 2 of the 2480 series manual to increase system capability.

Note that when HP-2480C's and HP-2480K's are used on the same bus of the combining case's mother board, the HP-2480K's will receive power from the 28 vdc master power supply output. A series dropping resistor may be required in the HP-2480K.

A-5 OPERATION

Operating controls and their functions are furnished in Table A-1 which follows:

Table A-1 HP-2480C Excitation Coupler Controls

Item	Control	Function
1	C. V. or C. I. Switch	Places the HP-2480C and the associated transducer in either the constant voltage or constant current mode of operation. When the switch is in the C.I. position the equipment operates in the constant current mode. The C.V. position is for the constant voltage mode.
2	EXCIT ADJ Control	This potentiometer provides adjustment of the excitation source output voltage or current depending on the operating mode.
3	+ or - Push-pull Switch	Changes the polarity of the excitation applied to the transducer. When the switch is pushed inward (only + of decal on top of switch visible), the bridge polarities (+ E and - E) are as shown in Figures 2-3 through 2-6 and when pulled outward (- and + of decal visible) + E and - E are reversed.
4	MON Switch	The MON switch enables the excitation voltage or current to be measured by an external meter. When depressed the MON switch connects the voltage or current component, as determined by the HP-2482N Monitor Function Selector, to an external meter. The MON switch includes contacts for switching the transducer guard line to the external meter (reducing common mode mode errors) and contacts that provide a closure to + cal power or the power common (as selected by item 6 of table 2-2) for external use as a control line. In a combining case, this control line prevents simultaneous operation of a signal monitoring function in more than one combining case at a time.

The typical operating procedures provided on pages 2-17 through 2-21 of the Preliminary Manual for the 2480 Series apply to configurations using HP-2480C's, Remember that the linear mode is not applicable and that:

a. Instructions for setting the HP-2480A's GAIN × 1 or × 6 switch are not applicable.

b. Instructions for setting the HP-2481A's SENSE switch are not applicable.

A-6. THEORY OF OPERATION

The HP-2480DC Excitation Source, Figure A-4, contains the following principal circuits:

a. DC reference source

b. DC amplifier

c. Control

d. Short circuit protection

A-7. DC Reference Source Circuit

The DC reference source circuit is made up of resistors R1 and R2 and avalanche diode CR1. Resistor R1 establishes the quiescent operating point of CR1. Multiturn potentiometer R2 (EXCIT ADJ control) is shunted across CR1. An adjustable dc input voltage connects from the wiper Arm of R2 of transistor Q1. Transistor Q1 is the input stage to the direct-coupled amplifier.

A-8. DC Amplifier Circuit

The DC amplifier is comprised of transistors Q1 through Q5. Transistors Q1 and Q2 constitute a differential amplifier that has transistor Q3 connected to their emitters as a constant current source. Transistor Q3, connected in this manner, stabilizes the quiescent operating point of the differential amplifier

The differential amplifier output, taken from the collector of Q2, drives the cascaded emitter followers Q4 and Q5. Open loop gain for the DC amplifier (from the base of Q1 to the emitter of Q5) is about 180, however, negative feedback from the output through resistors R10 and R11 to the base of Q2 reduces the gain to approximately 2. Resistor R3 and avalanche diode

CR2 are placed across the 28-volt input lines and their junction connected to the circuit common to provide + 22 volts and - 6 volts for circuit operation.

A-9 Control Circuits

The HP-2480C may be operated in either the constant voltage or constant current mode. As shown in Figure A-4, sections A, B, and D of C. V. of C. I. slide-switch S1 establish unity gain for the HP-2480C in the constant voltage mode. Section C shunts the constant current feedback resistor R20. When switch S1 is placed in the C. I. position, current feedvack resistor R20 is placed in the circuit and the constant current mode is in effect.

The + or - slide-switch S2, a push-pull front panel control, reverses the polarity of the excitation output. Transients produced during switch operation are suppressed by diodes CR3 and CR4, and the mechanical timing built into switch S2.

The MON slide-switch S3, a momentary pushbutton control on the front panel, samples circuit parameters for external monitoring. When pressed, the switch functions are as follows:

a. Provides for monitoring excitation voltage at pins 23 and 12 of combining case receptacle J31 or, if the combining case control board is connected to J31, at pins 23 and 24 of the control board's receptacles J1 or P2. Switch contact sets E and F provide this function.

b. Provides for monitoring excitation current at pins 11 and 10 of combining case receptacle J31 or, if the control board is installed, at pins 13 and 12 of the controls board's receptacle J1 or P2. Switch contact sets A, B, C and D provide this function.

c. Provides guard line to points of measurement of (a) and (b) above. Switch contact set G provides this function.

d. Provides 28-volt control signal from resistance bridge control board to point of measurement. Where more than one combining case is used, this control line also operates relays on the combining case control board to prevent simultaneous monitoring of signals. Switch contact set H provides this function.

A-10 Short Circuit Protection Circuit

The excitation output leads of the HP-2480C may be shorted with no damage to the instrument. Normal operation of the HP-2480C is restored with the removal of the short. The circuit which provides this short circuit protection consists of normally cut-off transistor Q6 and its associated components. When a short appears across pins 2 and 12 of P1, transistor Q6 is driven into conduction by the voltage drop across R16. When conducting, Q6 shunts the base current drive from transistor Q4 thereby limiting the output of the cascaded emitter followers to the approximate 80 ma.

A-11 MAINTENANCE

Maintenance instructions for the HP-2480C will be furnished in the complete manual for the 2480 series Signal Conditioning Equipment. As an aid to troubleshooting, the HP-2480C schematic, Figure A-4, is furnished.

A-12 PERFORMANCE CHECK FOR HP-2480C

The performance check for the HP-2480C is completed on an instrument plugged into the combining case's mother board. The required measurements are made at receptacle P2 of the combining case's control board. The following parameters are checked:

a. Minimum Excitation Output Voltage

b. Short circuit Current Limit

c. Maximum Excitation Output Voltage

d. Load Regulation

e. Line Regulation

f. Excitation Output Current (Constant Current Mode)

A-13 Test Equipment Required

The test equipment required includes the following:

a. Test cable as shown in Figure A-3. Make from:

1. Cable, HP part No. 8120-0129
2. Receptacle, HP part No. 12521-6014
3. Dual banana plug, HP part No. 1251-0005H, and single banana plug, HP parts No. 1251-0124H

b. Test plug as shown in Figure A-3. Make from dual banana plug, HP part No. 1251-0005H, and 300Ω, 10 watt resistor.

c. Electro-Scientific Industries SR-1 standard 1-ohm resistor.

d. Resistor board HP part No. 02481-6007 with balance resistors (R11 and R13) and bridge completion resistors (R7 through R10) not installed.

c. HP-2401C Integrating Digital Voltmeter or equivalent

A-14 Check-out Procedure

This check-out procedure employs the user-furnished 28-volt master power supply connected as shown in figure A-3. The master power supply is the normal source of power for a system that contains HP-2480C's .
Proceed as follows:

a. Set the C. V./C. I. switch on the HP-2480C to the C. V. position. On the HP-2481A Resistance Bridge's control board, set the EXC MON switch to the LOCAL position. Insert the HP-2481A control and resistor boards into the HP-2480C's case and the instrument case into the combining case. Push the + or - switch inward and rotate the EXCIT ADJ control fully counter clockwise.

b. Connect male dual and single banana plugs of the test cable to the appropriate receptacles of the DVM. Connect the test cable's receptacle J2 to receptacle P2 of the combining case's control board. Adjust the output of the master power supply to 26 volts.

c. While observing the DVM, press the MON switch on the HP-2480C. The DVM should indicate a minimum excitation output voltage of less than + 1. 0 volts.

d. While observing the DVM and pressing the MON switch, rotate the EXCIT ADJ control clockwise for a DVM reading within the limits + 1. 0 and + 1. 3 volts. Keep the MON switch pressed and pull the + or - switch to its outward position. The change in magnitude upon the reversal of excitation polarity should be no more than 1 millivolt. Restore the + or - switch to its inward position.

e. Insert male pin 1 and 2 of standard resistor SR1 into the female end of banana plug P1. While observing the DVM, press the MON switch on the HP-2480C. The DVM should indicate a short circuit current + 70 to + 90 milliamperes (+70 to +90 millivolts).

f. Remove the standard resistor SR1 from the banana plug P1. While observing the DVM, and pressing the MON pushbutton switch on the HP-2480C rotate the EXCIT ADJ control fully clockwise. The DVM indication should increase smoothly to a maximum excitation output voltage within the range + 12.5 to + 14.7 volts.

g. While observing the DVM and pressing the MON switch on the HP-2480C, rotate the EXCIT ADJ control counter clockwise for a DVM indication within the range + 12.5 to + 13.0 volts. Check load regulation by observing the DVM, pressing the MON switch and inserting banana plug P3/R1 into banana plug P1 and removing it. The 300-ohm load should not vary the DVM indication by more than 39 millivolts.

h. Insert banana plug P3/R1 into banana plug P1. While observing the DVM and pressing the MON switch, check line regulation by varying the master power supply's output over the range 26 volts to 28 volts. The DVM indication should not vary more than 100 millivolts. Remove banana plug P3/R1.

i. If it is desired to check the excitation output current of the HP-2480C in the constant current mode, remove the instrument case from the combining case and set the HP-2480C's C.V. or C.I. switch to the C.I. position. Rotate the HP-2480Cs EXCIT ADJ counter clockwise, reassemble, and replace the instrument in the combining case. Insert the standard resistor SR1 into the rear of banana plug 1. While observing the DVM and pressing the MON pushbutton on the HP-2480C, slowly rotate the EXCIT ADJ control clockwise. The DVM indication should vary smoothly over the range of at least 5 to 40 millivolts.

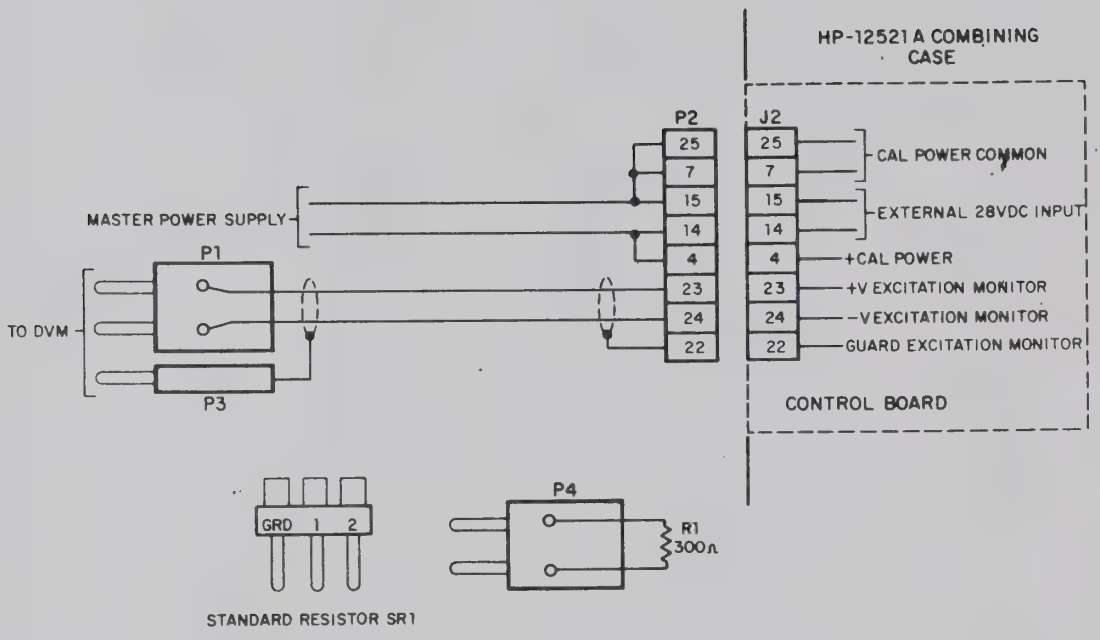

Figure A-3. Combining Case Connections Required for HP 2480C Check-Out

A-15 PARTS LIST

CIRCUIT REFERENCE	DESCRIPTION	STOCK NO.	MFR. CODE NO.	MFR. PART NO.	QTY.	1-YR. SPA.
	BASIC 2480C EXCITATION COUPLER					
A1	Etched Bd	2480-6007	04404	-	1	0
	Miscellaneous					
	Decal, name	7120-1933	04404		1	
	A1 ETCHED BD	2480-6009				
C1	C: fxd, my, .22 µf, 10%, 200 v	0160-0380	28480+	-	1	1
C2	C: fxd, my, .01 µf, 10%. 200 v	0160-0161	28480	-	1	1
C3	C: fxd, mica, 430 pf, 5%, 300 v	0160-0939	28480	-	1	1
C4	C: fxd, al-elect, 10 µf, -10 + 100%, 50 v	0180-0136	56289	40D106F050 DC4MI	1	1
CR1	Diode: avalanche, Si	1902-0761	12954*	1N821	1	1
CR2	Diode: avalanche, Si, 6.19 v	1902-0551	28480	-	1	1
CR3, 4	Diode: Si	1901-0025	28480	-	2	1
CR5	Diode: rect, Si	1901-0158	28480	-	1	1
J1	Conn: pc, 20 pin	1251-1671	95238	OBD	1	1
Q1-4, 6	Transistor: Si, NPN	1854-0071	28480	-	5	1
Q5	Transistor: Si, NPN	1854-0039	02735	2N3053	1	1
R1	R: fxd, ww, 1.5K, 5%, 3 w	0811-1805	28480	-	1	1
R2	R: var, ww, 2K, 5%, 2 w	2100-1900	28480	-	1	0
R3	R: fxd, metflm, 2.15K, 1%, 1/2 w	0698-3408	28480	-	1	1
R4	R: fxd, metflm, 464Ω, 1%, 1/8 w	0698-0082	28480	-	1	1
R5	R: fxd, metflm, 26.1K, 1%, 1/8 w	0698-3159	28480	-	1	1
R6, 8	R: metflm, 1.47K, 1%, 1/8 w	0757-1094	28480	-	2	1
R7	R: fxd, metflm, 1K, 1%, 1/8 w	0757-0280	28480	-	1	1
R9	R: fxd, metflm, 38.3K, 1%, 1/8 w	0698-3161	28480	-	1	1
R10	R: fxd, metflm, 2K, 1%, 1/2 w	0698-4313	28480	-	1	1
R11	R: fxd, metflm, 1.65K, 1%, 1/2 w	0698-6010	28480	-	1	1
R12	R: fxd, ww, 1K, 5%, 2 w	0812-0071	28480	-	1	1
R13, 18	R: fxd, metflm, 5.1K, 1%, 1/2 w	0757-0833	28480	-	2	1
R14, 17	R: fxd, metflm, 100Ω, 1%, 1/8 w	0757-0410	28480	-	1	1
R15	R: fxd, ww, 100Ω, 5%, 3 w	0813-0050	28480	-	1	1
R16	R: fxd, ww, 8Ω, 3%, 3 w	0812-0015	28480	-	1	1
R19	R: fxd, ww, 10Ω, 5%, 2 w	0811-1767	28480	-	1	1
R20	R: fxd, ww, 135Ω, 5%, 5 w	0812-0098	28480	-	1	1
S1A-D;2A-F;3A-H	Switch: slide, DPDT, 0.5a	3101-0070	79727	126B	9	1
	Miscellaneous					
	Decal, knob, R2	7120-1053	04404	-	1	
	Decal, pushbutton, S3A-H	7120-1080	04404	-	1	
	Decal pushpull, S2A-H	7120-1088	04404	-	2	
	Knob, R2	5020-5178	04404	-	1	
	Pushbutton, S3A-H	5040-1461	04404	-	1	
	Pushpull-button, S2A-F	5040-1462	04404	-	1	

MO183

* Not on Mfr. Code: 12954: Dickson Electronics, Scottsdale, Arizona

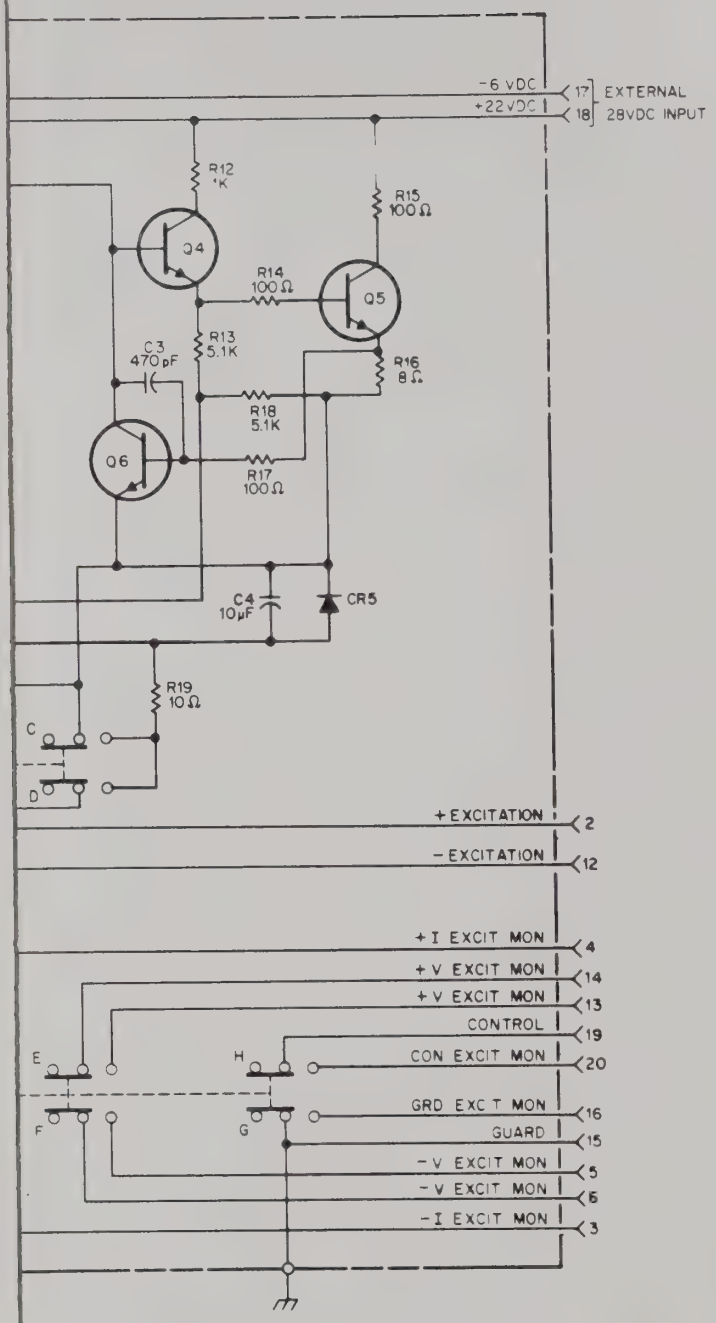

FIGURE A-4 HP-2480C EXCITATION COUPLER

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	Miscellaneous					
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	A1 ETCHED BD	2480-6009				
C1	C: fxd, my, .22 µf, 10%, 200 v	0160-0380	28480+	-	1	1
C2	C: fxd, my, .01 µf, 10%. 200 v	0160-0161	28480	-	1	1
C3	C: fxd, mica, 430 pf, 5%, 300 v	0160-0939	28480	-	1	1
C4	C: fxd, al-elect, 10 µf, -10 + 100%, 50 v	0180-0136	56289	40D106F050 DC4MI	1	1
CR1	Diode: avalanche, Si	1902-0761	12954*	1N821	1	1
CR2	Diode: avalanche, Si, 6.19 v	1902-0551	28480	-	1	1
CR3, 4	Diode: Si	1901-0025	28480	-	2	1
CR5	Diode: rect, Si	1901-0158	28480	-	1	1
J1	Conn: pc, 20 pin	1251-1671	95238	OBD	1	1
Q1-4, 6	Transistor: Si, NPN	1854-0071	28480	-	5	1
Q5	Transistor: Si, NPN	1854-0039	02735	2N3053	1	1
R1	R: fxd, ww, 1.5K, 5%, 3 w	0811-1805	28480	-	1	1
R2	R: var, ww, 2K, 5%, 2 w	2100-1900	28480	-	1	0
R3	R: fxd, metflm, 2.15K, 1%, 1/2 w	0698-3408	28480	-	1	1
R4	R: fxd, metflm, 464Ω, 1%, 1/8 w	0698-0082	28480	-	1	1
R5	R: fxd, metflm, 26.1K, 1%, 1/8 w	0698-3159	28480	-	1	1
R6, 8	R: metflm, 1.47K, 1%, 1/8 w	0757-1094	28480	-	2	1
R7	R: fxd, metflm, 1K, 1%, 1/8 w	0757-0280	28480	-	1	1
R9	R: fxd, metflm, 38.3K, 1%, 1/8 w	0698-3161	28480	-	1	1
R10	R: fxd, metflm, 2K, 1%, 1/2 w	0698-4313	28480	-	1	1
R11	R: fxd, metflm, 1.65K, 1%, 1/2 w	0698-6010	28480	-	1	1
R12	R: fxd, ww, 1K, 5%, 2 w	0812-0071	28480	-	1	1
R13, 18	R: fxd, metflm, 5.1K, 1%, 1/2 w	0757-0833	28480	-	2	1
R14, 17	R: fxd, metflm, 100Ω, 1%, 1/8 w	0757-0410	28480	-	1	1
R15	R: fxd, ww, 100Ω, 5%, 3 w	0813-0050	28480	-	1	1
R16	R: fxd, ww, 8Ω, 3%, 3 w	0812-0015	28480	-	1	1
R19	R: fxd, ww, 10Ω, 5%, 2 w	0811-1767	28480	-	1	1
R20	R: fxd, ww, 135Ω, 5%, 5 w	0812-0098	28480	-	1	1
S1A-D;2A-F;3A-H	Switch: slide, DPDT, 0.5a	3101-0070	79727	126B	9	1
	Miscellaneous					
	Decal, knob, R2	7120-1053	04404	-	1	
	Decal, pushbutton, S3A-H	7120-1080	04404	-	1	
	Decal pushpull, S2A-H	7120-1088	04404	-	2	
	Knob, R2	5020-5178	04404	-	1	
	Pushbutton, S3A-H	5040-1461	04404	-	1	
	Pushpull-button, S2A-F	5040-1462	04404	-	1	

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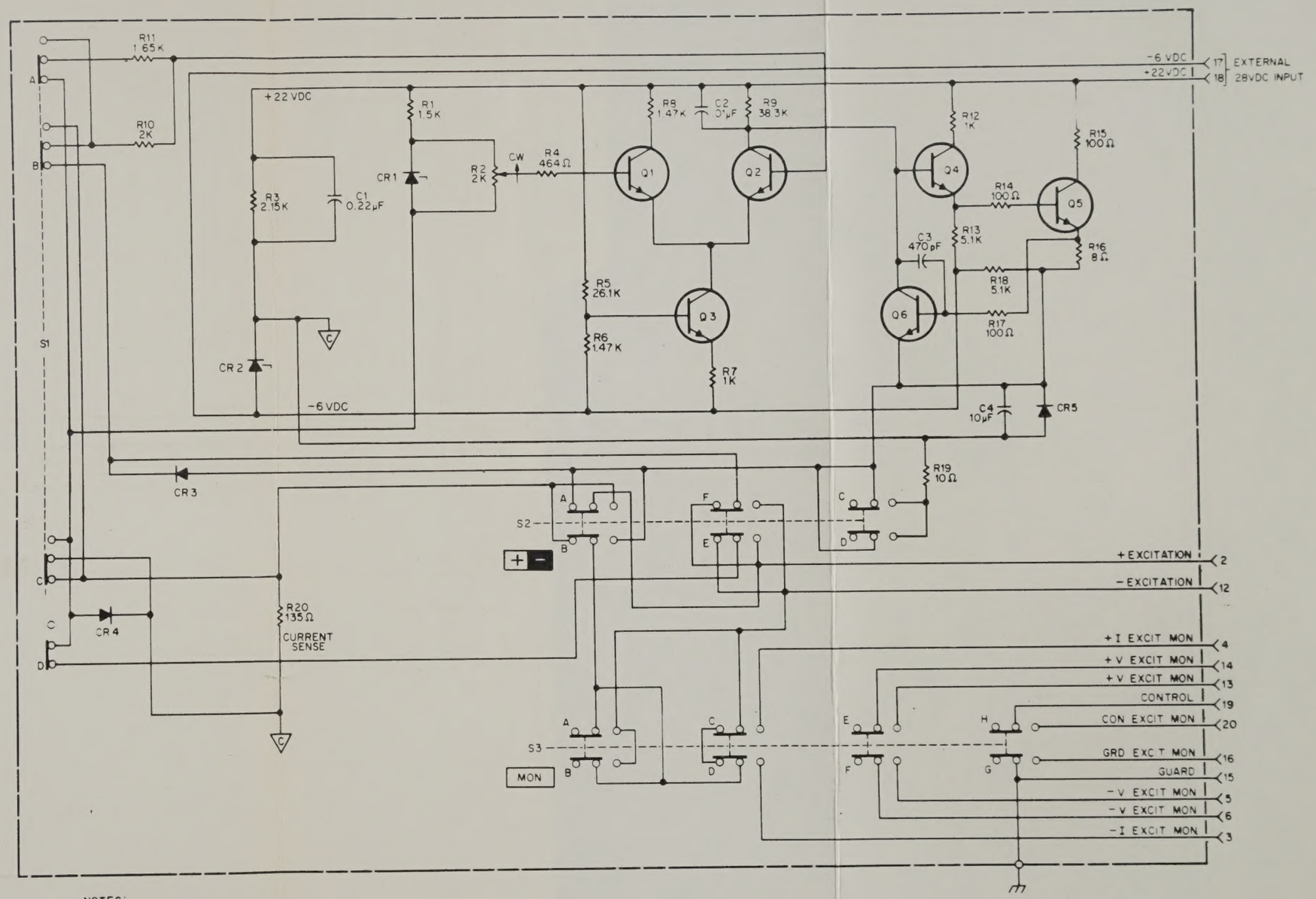
* Not on Mfr. Code: 12954: Dickson Electronics, Scottsdale, Arizona



NOTES:

CIRCUIT REFERENCE POINT FOR VOLTAGES SHOWN

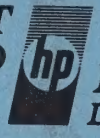
INSTRUMENT CASE (GUARD)

SWITCH POSITIONS
S1 CONSTANT VOLTAGE
S2 +VE
S3 MONITOR OFF

C-02480-6009-2

FIGURE A-4 HP-2480C EXCITATION COUPLER

HEWLETT PACKARD



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